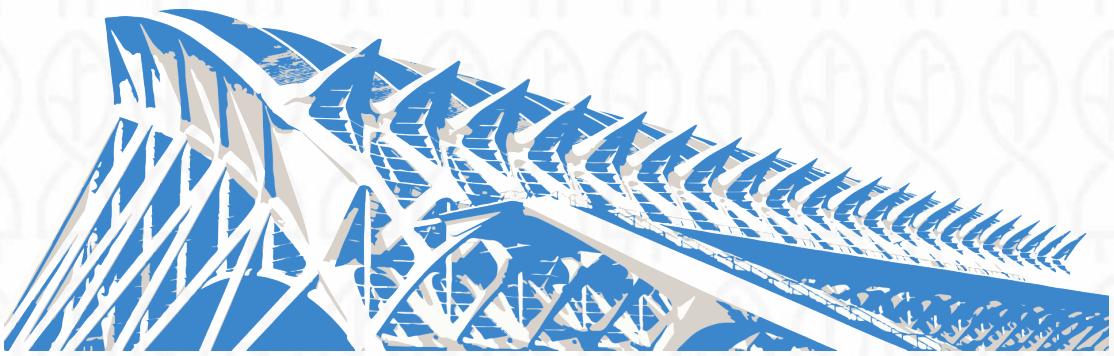
First International Conference on Sustainable Energy Education (SEED 2024)

Book of proceedings

SEED
sustainable energy education

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

edUPV
Universitat Politècnica de València



First International Conference on Sustainable Energy Education (SEED 2024)

Valencia, Spain, 3-5 July 2024

edUPV
Universitat Politècnica de València

Congress UPV
Proceedings of the First International Conference on Sustainable Energy Education (SEED 2024)

The contents of this publication have been double-blind peer-reviewed by the Program Committee.

© Scientific Editors

Elena de la Poza Plaza
Amparo Blázquez-Soriano
Ruijing Wang
Annamaria Sereni

© Texts The authors

© Publisher

2024, Editorial Universitat Politècnica de València
Cno. de Vera, s/n.
46022 Valencia (SPAIN)
www.lalibreria.upv.es / Ref.: 6795_01_01_01

ISBN 978-84-1396-271-9
DOI http://dx.doi.org/10.4995/SEED2024.2024.19007

First International Conference on Sustainable Energy Education (SEED 2024)
This book is licensed under a Creative Commons Atribution-NonCommercial-ShareAlike-4.0 International license
Editorial Universitat Politècnica de València http://ocs.editorial.upv.es/index.php/SEED/SEED2024

Organizing Committee

General chair

Elena de la Poza Plaza, Universitat Politècnica de València

Vice-chair

Amparo Blázquez-Soriano, Universitat Politècnica de València

Scientific committee

Martijn Rietbergen, University of Applied Science Utrecht

Mariola Guarinos, AVAESEN

Evridiki Mantela, Bioeconomy and Environment Cluster Western Macedonia

Semih Severengiz, Bochum University of Applied Sciences

Local organization

María Natividad Guadalajara Olmeda, Universitat Politècnica de València

Pedro Fuentes Durá, Universitat Politècnica de València

Ruijing Wang, Universitat Politècnica de València

Annamaria Sereni, Politecnico di Milano

Alberto Celani, Politecnico di Milano

Program Committee

Maria Ángeles Alcaide González, Universitat de València

Catarina Afonso, Instituto Politécnico de Leiria

Joyce Aguiar, Centre for Research in Higher Education Policies

Ingrid Ahrens Massey, Northeastern State University

Safaa Al Tameemi, Munster Technological University

Rolando Angel-Alvarado, Universidad Pública de Navarra

Elisa Alen, University of Vigo

Nazim Ali, Keele University

Paula Álvarez Huerta, Mondragon Unibertsitatea

Inmaculada Aranaz, Universidad Complutense De Madrid

Núria Arenas Peiró, IES Maria Ibars, Denia

Pablo Arés Gastesi, CEU San Pablo

Sami Areva, Solar Finland Ltd

Elena Arroyo, Universidad Complutense de Madrid

Sarah Aynsley, Keele University

Mercedes Elisa Aznar Jimenez, Florida Universitària

Johan Baldeon, Pontificia Universidad Católica del Perú

Robert Barthorpe, University of Sheffield

Mª Elvira Barrios Espinosa, University of Málaga

Anita Batisti, Fordham University

Fernando Battista, Università di Roma Tre

Mi-Yong Becker, Bochum University of Applied Sciences

Werner Beyerle, Karat EDV Ltd & Co KG

Lucía Bellés Calvera, Universitat Jaume I

Dina Berzina, University of Latvia

Jorrit Bock, Royal Haskoningdhv

Sofia-Natalia Boemi, Cluster of Bioeconomy and Environment of Western Macedonia

Montserrat Boronat Navarro, Universitat Jaume I

Naomi Braithwaite, Nottingham Trent University

Alma Maria Cabanes Machancoses, CIPFP Vicente Blasco Ibáñez, València

Maria Giulia Cantiani, University of Trento

Javier Carballeira Morado, Universitat Politècnica de València

Daniela Casiraghi, Politecnico di Milano

Valeria Caviezel, University of Bergamo

Alberto Celani, Politecnico di Milano

Cristiana Cervini, University of Bologna

Guido Charosky, Universitat Politècnica De Catalunya

Augusto Cocorullo, University of Naples Federico II

Todd Cochrane, Nelson Marlborough Institute of Technology

Pauline Collins, University of Southern Queensland

Erika Corradini, University of Southampton

Jelena Davidova, Daugavpils University

Raúl De Arriba Bueno, Universitat de València

Diane Debacker, University of Kansas

Jiska De Groot, University of Cape Town

Olga Maria Diaz Godoy, Universidad de Los Llanos

Stefanos Dodouras, Cluster of Bioeconomy and Environment of Western Macedonia

Faith Dowelani, University of Pretoria

Yolanda Echegoyen Sanz, Universitat de València

Katalin Eklicsné Lepenye, University of Pécs

Estefanía Mourelle Espasadín, Universidade da Coruña

Ana Estima, University of Aveiro

Juraj Fabus, Zilinska Univerzita V Ziline

Yannis Fallas, Cluster Of Bioeconomy And Environment Of Western Macedonia

Jonathan Fanning, University of York

Miguel Ferrando Rocher, Universidad de Alicante

Paula Figas, Kempten University of Applied Sciences

Tania Fernández Navarro, Regional General Directorate of Vocational Training (GVA)

Nuno Flores, Universidade do Porto

Efrén Forcada Gallén, CIPFP Vicente Blasco Ibáñez, València

Pedro Fuentes, Universitat Politècnica de València

Diego Galego, University Aveiro

César García, Universidad Politécnica de Madrid

Moisés García Morales, Universidad de Huelva

Suzanne Gatt, University of Malta

Stefanos Gerardis University of Western Macedonia

Ramón Gero, Eiffage SA

Giorgio Giorgi, Universidad Complutense de Madrid

Tanja Glusac, Curtin University

Boudewijn Grievink, Katapult

Mariola Guarinos Ripoll, Avaesen

Maria Lucia Guerrero Farias, Universidad de Los Andes

Rabah Halabi, Oranim College

Minna Harju, Raisio Regional Education and Training Consortium

Jessica Harris, State University of New York

Aleksi Heinonen, Turku University of Applied Sciences

Kalle Hentula, Salo Solar Ltd

Katrin Herget, University of Aveiro

Fionna Heuff The Raisio Regional Education and Training Consortium

Carme Huguet, Universidad de Los Andes

Gerben Huiszoon, Scalda

Valasia Iakovoglou, Unesco and International Hellenic University (Ihu)

Nagore Ipiña, Mondragon Unibertsitatea

Marinela Istrate, University of Iasi

Magdalena Jiménez, University of Granada

Beatriz Jimenez Parra, Universidad de León

Isabel João, Instituto Superior de Engenharia de Lisboa

Kostas Karamarkos, Just Transition Institute

Natassa Kazantzidou, IDEC

Monique Keevy, University of Johannesburg

Kimmo Keinästö, RASEKO

Marlena Kilian, Cardinal Stefan Wyszynski University

Andreas Knie, Berlin Social Science Center

Theofano Kollatou, University of Western Macedonia

Safak Korkut, University of Applied Sciences and Arts Northwestern Switzerland

Miriam Korstanje, Katapult

Athina Krestou, University of Western Macedonia

Angelique Kritzinger, University of Pretoria

Aleksandra Kulpa-Puczynska, Uniwersytet Kardynała Stefana Wyszyńskiego

Emmanuel Kypraios, Maynooth University

Ignacio Laiton Poveda, Instituto Técnico Central Bogotá

Damian Lampert, Universidad Nacional de Quilmes

María Landín, Universidad Veracruzana

Yvette Lanting, University of Applied Science Utrecht

Jan Lauwerijssen, Roc Midden Nederland

Anna Logan, Dublin City University

Pauline Logue, GMIT, Atlantic Technological University

Gaia Leandri, Università Degli Studi Di Genova

Carlos Lerma Elvira, Universitat Politècnia de València

Luca Andrea Ludovico, Università degli Studi di Milano

Bence Lukacs, Technische Hochschule Nürnberg Georg Simon Ohm

José Manuel Luna Vicente, IES La Marxadella, Torrente

Inese Lusena Ezera, Liepaja Universiy

Nicolaas Luwes, Central University of Technology

Francesco Maria Mancini, Curtin University

Marco Manfra, University of Ferrara

Evridiki Mantela, Bioeconomy and Environment Cluster Western Macedonia

George Marnellos, Aristotle University of Thessaloniki

Stergios Maropoulos, University of Western Macedonia

Susana Martí Sendra, IES María Ibars, Denia

Teresa Martín García, Universidad de Salamanca

Robert Martínez Carrasco, Universitat Jaume I

Mónica Martínez Gómez, Universitat Politècnica de València

Loreto Mate Satué, Universidad de Zaragoza

Lorena Mathien, SUNY Buffalo State

Eleonora Mattarelli, La Sapienza University

Valeria Medarova, School of Management Bratislava

Noemí Merayo, Universidad de Valladolid

Paloma Merello Gimenez, Universitat de València

Carla Isabel Montagud Montalva, Universitat Politècnica de València

Gemma Montalvo, University of Alcalá

Elvira María Montañés Brunet, Universitat de València

Darlinda Moreira, Universidade Aberta

Ana S. Moura, University of Porto

Giulia Mura, Università Degli Studi di Milano-Bicocca

Gabrielle Murray, RMIT Univeristy

Gundeea Narrainen, University of Mauritius

Annie W.Y. Ng, Hong Kong University of Science and Technology

Nikos Ntavos Cluster of Bioeconomy and Environment of Western Macedonia

María Isabel Núñez Peña, University of Barcelona

Paul O'Leary, Waterford Institute of Technology

Cesar Ortega-Sanchez, Curtin University

Valentina Pagani, CISRE, Cà Foscari University fo Venice

Ayanda Pamella Deliwe, Nelson Mandela University

Maria Isabel Pardo Baldoví, Universitat de València

Cristina Pardo García, Universitat de València

Bartolomé Pascual Fuster, Universitat de les Illes Balears

Preeti Patel, London Metropolitan University

Dieter Pawelczak, Universitat der Bundeswehr Muenchen

Priyeshni Peiris Perera, University of Visual & Performing Arts

Úrsula Pérez, Ampere Energy

Jesus Perez Dasilva, University of The Basque Country

Adamaria Perrotta, UCD

Margarida Pinheiro, Universidade de Aveiro

Rosalina Pisco Costa, Universidade Nova de Lisboa

Antonella Poce, University of Modena and Reggio Emilia

Dimitri Prandner, Johannes Kepler University of Linz

Natalija Prokofjeva, Riga Technical University

Tomi Raassina, Salo Tech Ltd

Justin Rami, Dublin City University

Mario Ramírez, Universidad de San Carlos de Guatemala

Càndid Reig Escrivá, Universitat de València

Marta Retamosa Ferreiro, Universidad de Castilla-La Mancha

Martijn Rietbergen, University of Applied Science Utrecht

Elina Riivari, University of Jyvaskyla

Clementina Rios, Universidade do Porto

Iñigo Rodríguez, University of Almería

Marta Rojo Arce, University of Burgos

Alina Romanovska, Daugavpils University

Carlos Jesus Rosa Jiménez, Universidad de Málaga

Birgit Rösel, OTH Regensburg

Angelique Ruiter, University of Applied Science Utrecht

Daniel Sampaio, IPMAIA – Instituto Politécnico da Maia

Juan Antonio Sánchez Serrano, IES Antonio Navarro Santafé, Villena

Jessica Sandland, Massachusetts Institute of Technology

Sirats Santacruz, Mondragon Unibertsitatea

Antoinette Schembri, University of Warwick

Corinne Scicluna, University of Malta

Vicente Sebastián Alapont, Grupo Etra

Semih Severengiz, Bochum University of Applied Sciences

Olena Shliakhovchuk, Universitat Politècnica de València

Aleksandrs Skvorcovs, RISEBA University of Business, Arts and Technology

Oscar Smeets Roc Midden Nederland

Stephan Sommer, Bochum University of Applied Sciences

Noelia Ángel Soriano Regional General Directorate of Vocational Training (GVA)

Dimitrios Stimoniaris, University of Western Macedonia

Asya Stoyanova-Doycheva, University of Plovdiv

Conradus Suhre, University of Groningen

Fátima Suleman, Instituto Universitário de Lisboa (ISCTE-IUL), DINAMIA'CET

Hong Tao, Hong Kong University of Science and Technology

Maria Teresa Tascon, University of León

Orlanda Tavares, A3ES

Tatjana Titareva, RISEBA University

Tobi Thompson, Northeastern State University

Vicente Ramon Tomas Lopez, Universitat Jaume I

Pedro Fresco Torralba, AVAESEN

Ana Cristina Torres, Universidade do Porto

Martha Liliana Torres Barreto, Universidad Industrial de Santander

Dragos Truscan, Åbo Akademi University

Teemu Tuomela The Raisio Regional Education and Training Consortium

Emma Arianna Manuela Turian, Northeastern Illinois University

Gorka Unzueta, Mondragon Unibertsitatea

Mara Valente, University of Roma Tre

Yorrick Van Bree, Katapult

Frans Van den Akker, Royal Haskoningdhv

Tess Van der Hoek, Katapult

Lenny Van Onselen, University of Applied Science Utrecht

Eneko Jokin Uranga Santamaria, University of The Basque Country

Elisabetta Venezia, University of Bari Aldo Moro

Guilherme Victorino, Universidade Nova de Lisboa

Cristina Vilaplana-Prieto, University of Murcia

Domenico Vito, Università degli Studi di Pavia

Inta Volodko, Riga Technical University

Zuzana Vranayová, Technical University of Kosice

Olli Vuorinen, RASEKO

Domenik Wolff-Boenisch, Curtin University

Jennifer Wood, Prifysgol Aberystwyth University

Angela Wright, Munster Technological University

Katerina Zdravkova, University Ss. Cyril and Methodius

Ana Zorio Grima, Universitat de València

Supporters

Co-funded by the European Union

This publication was produced in the framework of the CoVE SEED project, co-funded by the European Union under the Erasmus+ Programme, Grant Agreement No 101056147.

Co-Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Technical Partner

Sponsor

Prologue

This volume contains the selected extended abstracts of the First International Conference on Sustainable Energy Education (SEED 2024) held in Valencia, Spain 3-5 July 2024.

In its first edition, the SEED conference has become the leading forum for lecturers of vocational training and higher education, researchers, policymakers, and practitioners to exchange ideas and experiences and tackle the challenges of the energy transition to facilitate well-equipped learners, students, professionals, and suitable labor capacity in an environment in which technologies constantly evolve.

During the conference, the partners have co-created and increased not only regional cooperation but also transnational cooperation. Good practices and innovative approaches for learning with impact have been exchanged in the form of oral and poster presentations and developed in the form of workshops.

The SEED conference was designed as the strategic tool for transnational learning and cooperation of the European co-funded project CoVE SEED (Centre of Vocational Excellence – Sustainable Energy Education), focused on providing excellent and innovative education to become a fossil-free energy world.

SEED sees education as an important driver for innovation and growth, agile in adapting to the labor market. The objectives of the conference and ultimately the project are therefore focused on innovative energy education that meets the needs of the labor market: a) Preparing learners, students, and professionals with skills and competencies for the future; b) Empowering regional innovation based on regional needs; c) Upscaling and promote work-based education, and will lead to d) The establishment of an international learning community and e) establishment of Centres of Vocational Excellence (CoVES).

The CoVE SEED project consists of educational providers (EQF level 2-7), working professionals, and policymakers from Spain, The Netherlands, Greece, Germany, and Finland. The result is an international community dedicated to sustainable energy continuously growing by activities such as the SEED conference. and *co*-funded by the European Union. Erasmus+ under grant agreement No 101056147.

The selection of the scientific program was co-directed by Dr. Elena de la Poza Plaza, Dr. Amparo Blázquez Soriano, Dr. Martijn Rietbergen, Ms. Mariola Guarinos, PhD candidate Evridiki Mantela, and Dr. Semih Severengiz, who led a team of 220 program committee members representing 33 countries in five continents.

Following the call for papers, the conference received 180 extended abstracts and 30 workshops from 35 different countries. At least two program committee members reviewed all the submitted extended abstracts under a double-blind review process. The proposal for workshops was also peer-reviewed by the scientific committee. Finally, 114 extended abstracts were accepted to be presented during the conference:

85 as oral presentations and 29 as posters. All of them are published by the UPV Press in this volume. In addition, 18 workshops were accepted to be hosted during the conference. The assessment and selection process ensures a high-quality program greatly valued by the research and practitioners' communities.

Considering both the origin of the participants and of the program committee members, 53 different countries in total are represented. This demonstrates the great international dimension of the event and how we succeeded in our strategy for transnational learning through the SEED conference.

SEED also featured four Keynote Speakers and one Honored Guest Speaker who overviewed important current topics: Prof. Francisco Beltrán from KTH Royal Institute of Technology in Sweden discussed *the Nordic approach to sustainable energy education*. Dr. Débora Domingo and Dr. Nuria Matarredona from Universitat Politècnica de València, Msc. Davide Roletto from Climology and Msc. Eugenio Domínguez Amarillo from Hybrid Energy Storage Solutions Ltd. discussed *Priorities for Sustainable Energy Education*. The session was moderated by SEED Honored Guest Speaker Prof. Dr. Edward. S. Rubin from Carnegie Mellon University.

The conference was hosted by the Faculty of Business Administration and Management of the Universitat Politècnica de València, ranked as the best technical university in Spain by the Academic Ranking of World Universities (ARWU) since 2018. Valencia is a city of culture and heritage. It is the third largest city in Spain, and its location on the shore of the Mediterranean Sea provides its citizens and visitors with privileged weather.

The organizing committee would like to thank our supporters and sponsors, especially Istobal who made this conference a great success. Also, thanks are indebted to the invited speakers, authors, program committee members, reviewers, session chairs, presenters, supporters, and all the attendees.

Our final words of gratitude must go to the Faculty of Business Administration and Management of the Universitat Politècnica de València for supporting and making it possible to become a great event.

Elena de la Poza Plaza
Amparo Blázquez Soriano
Ruijing Wang
Annamaria Sereni

Scientific Editors

List of workshops

1. **Enabling the flow of knowledge for the Energy and Hydrogen Transition**
   Chairs: Marsha Wagner, Jan Geurt van Kessel, Pim Opraus and Yvette Lanting
   Organizations: Energy Innovation NL, GroenvermogenNL, HAN University of Applied Sciences

2. **Sustainable Energy Education: Delivering the energy workforce of the future**
   Chairs: Mascha Moorlach and Jacqueline Garcia
   Organization: Transforming Energy Access – Learning Partnership (TEA LP)

3. **ESExNBS@NEB - Exploring Sustainable Education implementing the Nature-Based Solution in the New European Bauhaus perspective**
   Chairs: Elena Mussinelli and Ellie Mavroudi
   Organizations: ENVI-Reg Observatory (Politecnico di Milano) & Cluster of Bioeconomy and Environment of Western Macedonia (CluBE)

4. **MINDS – Meaningful Immersive Narratives Driving Sustainability**
   Chairs: Karolien Van Riel and Rob De With
   Organization: AP Hogeschool Antwerpen

5. **Game-based Learning for Sustainability in Management Education (GAME-SME)**
   Chairs: Fabio Nonino, Luca Fraccascia and Mirko Giagnorio
   Organization: Sapienza University of Rome

6. **Empowering Through Education: T-Shore's Approach to Wind Turbine Technician Training (T-shoreEdu)**
   Chair: Gerben Huiszoon
   Organization: The T-shore Project partners

7. **Build your own LEAF: Learning Ecosystem Taking Action for the Future**
   Chairs: Linette Bossen and Saskia Postema
   Organization: Delft University of Technology

8. **Sustainable Business Models in practice: a business game competition (BG-COMP)**
   Chairs: Fabio Nonino, Luca Fraccascia and Mirko Giagnorio
   Organization: Sapienza University of Rome

9. **Unlocking African green hydrogen potential for mutual benefit cooperation with Europe**
   Chair and organization: JUST GREEN AFRH2ICA consortium

10. **Unveiling Training and Skill Requirements for Driving the Adoption of Emerging Technologies in the Renewable Energy field - RE-SKILLS Workshop**
    Chair and organization: LOMARTOV

11. **Attract and train European technicians in Energy Transition**
    Chairs: Gregorio Blanco Sáez and Anabelle Moriceau
    Organizations: Centro de Formación Profesional XABEC & Smart Energy Systems Campus

12. **Transforming Sustainable Energy Education (TranSEED)**
    Chairs: Jan Lauwerijssen, Carme Huguet, Fernando Pascual Fuentes and Julian Mateo Muñoz
    Organizations: The Netherlands ROC Midden Nederland, The Netherlands Environmental Science and Sustainability group, IE University, School of Science and Technology, IE University, Spain GVA & IES Alto Palancia, Segorbe (Castellón) – CFSRE Higher Cycle of Renewable Energies.

13. **Applied and Innovative Research within VET Education for the Energy transition**
    Chairs: Barbara van Ginneken, Prof. Dr. Henning Klaffke, Dirk de Wit and Miriam Korstanje
    Organizations: The project partners of the AIRinVET project (ISSO, BHH, Katapult network and CoP of the Erasmus+ CoVE)

14. **H2 VIRTUAL TRAINING**
    Chairs: Dr. Michel Galaup, Dr. Maria Gonzalez Martinez, Pr. Pierre Lagarrigue, Dr. Valérie Lavergne Boudier and Dr. David Panzoli
    Organization: Institut National Universitaire Champollion

15. **Facilitating upliftings in solar energy storage (FUSES)**
    Chairs: Úrsula Pérez Ramírez
    Organization: Ampere Energy

16. **Challenges of International Master Degree Courses in Renewable Energy Systems**
    Chairs: Andreas Wolf
    Organization: Vela Solaris AG (Winterthur, Switzerland)

17. **Explore integration of sustainability in education from a reflexive, SDG and entrepreneurship perspective**
    Chairs: Lenny van Onselen and Sofia Pouri
    Organizations: HU University of Applied Sciences & CLuBE

18. **Accelerate matchmaking in a network: what can we learn from trees and computers?**
    Chairs: Frans van den Akker and Eugene Zaaijer
    Organizations: Royal Haskoning DHV & Hogeschool Utrecht

Index of communications

Track 1: Teaching and Learning on Sustainable Energy Education

Agroecology and Energy Sustainability at IES "Las Norias": A Solidarity Project for the Most Vulnerable Families 1
Cristóbal Sánchez Lozano, Gabriel Giménez Cisilino and Rubén José Ferrández Ballester

Using heat-loss in buildings as a concept to foster sustainability and systems thinking in students 9
Lorenzo Galante, Irina Mancheva, Stefano Fantucci and Valentina Serra

Analysis of the contribution to sustainable energy training of the degrees taught at the ETSII of the UPV 18
Jose Felipe Villanueva López, Ana Valles Lluch, Andrés Lapuebla Ferri, Ana Esteso Álvarez, Sergio Gallardo Bermell, María Sancho Fernández and Angel Ortíz Bas

Escaperoom in energy education 25
Joost Jongen

Aeromimetics 34
Juan Antonio Sánchez Serrano

A full integrated teaching method. The experience of a postgraduate master's degree in building energy efficiency design 42
Matteo Iommi, Angelo Figliola, Nico Monteferrante and Giuseppe Losco

EnerGPT – Enhancing Energy Literacy Education by Customizing ChatGPT 52
Thimo Schulz, Kim K. Miskiw, Christina Speck and Christof Weinhardt

Stimulating Metering Applications based on Renewables Technologies: presenting the SMART Project 62
Vasiliki Kotoula, Christina Panagiota Malliou, Evangelia Rigati, George Chatzargyros, Dimitrios Stimoniaris and Dimitrios Tsiamitros

Teaching and Learning of Renewable Energy in Remote and Dispersed Pacific Islands 71
Sekove Vodo and Ramendra Prasad

Digital educational tool on energy efficient retrofitting of buildings 79
Jose Alberto Diaz Angulo, Silvia Soutullo Castro, Maria Nuria Sánchez Egido and Emanuela Giancola

Upskilling of automotive engineers into electric and hybrid vehicles engineers in Greece **88**
Georgios Tsiranidis, Theocharis Xenitopoulos, Dimitrios Tsiamitros, Dimitrios Stimoniaris, Margarita Vatista, George Scroubelos, Theofano Kollatou, Athina Krestou, Ioannis Lamprakakis and Andreas Maropoulos

Upskilling and Reskilling on H2 technologies: The Green Skills for Hydrogen Project **97**
Athanasia Ioannidou, Ioanna Mikrouli, Evridiki Mantela, Eleni Papista and Nikolaos Ntavos

Energy-Campus Feuchtwangen: Sustainable energy education for supporting decarbonization in semi urban areas **105**
Haresh Vaidya and Kanav Bhalla

Solar energy and efficiency at IES El Cabanyal **112**
Ramon Soria, David Sornosa and IES El Cabanyal

Towards a more sustainable university campus: the case of ETSII LivingLab at Universitat Politècnica de València (Spain) **120**
Carla Montagud Montalvá, Javier Sanchis Saez, Javier Soriano Olivares, César Pagani Quiroga, Guillermo Escrivá Escrivá and Raúl Simarro Fernández

Teaching and Learning of Microgrids for Secondary School Learners – a Renewable Energy Sustainability Strategy for East African Communities **128**
Paul Bogere, Alexander Belov and Katrin Temmen

Facilitating evaluation and innovation of regional centers of vocational excellence in sustainable energy education **137**
Evelien Ketelaar, Lenny van Onselen, Angelique Ruiter and Yvette Lanting

Context-Sensitive Multidisciplinary Curriculum for Sustainable Energy Access Education **146**
Ogheneruona Diemuodeke, Tobinson Briggs and Mohammed Ojapah

Energy poverty training awareness in vocational and technical education **153**
Sofia Natalia Boemi, Stavros Spyridakos, Stefania Zourka, Evridiki Mantela, Stefanos Dodouras, Nikolaos Ntavos and Ioannis Fallas

Challenge-based control education in a master module of renewable energy systems **161**
Georg Pangalos, Carlos Cateriano Yáñez, Timon Kampschulte and Gerwald Lichtenberg

Development of Practical Research-Led Teaching Activities Using a Low Carbon Heating and Storage System **169**
Robert Barthorpe

Renewable Energy Management Education: Case Study of Birzeit University **176**
Ahmed Abu Hanieh

Track 2: Partnerships, Collaboration on Sustainable Energy Education

Project-based education: Business assignment manual **184**
Jan Lauwerijssen

S3 INDUSTRIA: A collaboration project between vocational education training and industrial sector **193**
Ramon Díaz, Aina Casabán, Lorena Muñoz, Elisa Adell, Paula Guillén and María José Sales

Exploring partnerships between universities, industry and governments to integrate Sustainable Development Goals **202**
Konstantinia Nikolaidou, Sofia Pavlidou, Ioannis Karagiannis and Lefteris Topaloglou

The role of universities and civil society's engagement in fostering entrepreneurship in energy transition and climate change **211**
Sofia Pavlidou, Konstantinia Nikolaidou, Lefteris Topaloglou and Rafaella-Eleni P. Sotiropoulou

Enabling the flow of knowledge for the Energy and Hydrogen Transition **220**
Marsha Wagner, Jan Geurts van Kessel and Rob de Jeu

Broadening horizons, sustainable development in education **230**
Ramon Soria, David Sornosa and IES El Cabanyal

Fighting Energy Poverty through multi-level energy education: the "Citizen School for the Right to Energy" in the City of Valencia (Spain) **237**
Noemi Garcia-Lepetit, Claudia Ferre, Pilar Jorda, Elena Rocher, Belén Costa-Ruiz, Sara Igual, Arturo Zea, Corentin Girard, Jorge Valls, Victoria Pellicer-Sifres and Pepa Ambrosio-Albala

Valorisation of the Renewable Energy Capacity Building in Kenya **246**
Dr. Francis Xavier Ochieng, Joseph Ngugi Kamau and Ephantus Kamweru

Environmental and Energy Management Systems (EEnMS) in Salesian Educational Institutions in Ecuador **261**
Xavier Serrano-Guerrero, John Calle-Siguencia, Pablo Arévalo-Moscoso, Fernando Pesantez-Avilés and Juan Cárdenas-Tapia

Understanding VET skills needs for enhancing the energy transition **270**
Martijn Rietbergen and Aleksi Heinonen

Zero Time, Zero Investment: Innovative Strategies for Sustainable Energy Development in Underdeveloped Countries **279**
Aleena Ahmad, Kiran Siraj, Muhammad Arslan Malik, Hafiz Owais Ahmad Khan and Naveed Arshad

Sustainable Mobility **290**
Matias Sanchez García, Carlos Llorca, Carlos Hernández Vicente, Mercedes Llorens Nicolau and Daniel Francés Belda

Discoveries from a Skills Evaluation on Sustainable Energy in Western Macedonia, Greece **297**
Stefanos Gerardis, Athina Krestou, Stergios Maropoulos, Alkiviadis Tsamis, Adam Stimoniaris, Sofia Papanikolaou, Nikolaos Ntavos, Sofia-Natalia Boemi, Stefanos Dodouras and Evridiki Mandela

Upskilling HVAC technicians on heat pump technologies for green energy transition **307**
Elisa Peñalvo-López, Vicente León-Martínez, Mar Cañada Soriano and Iván Valencia Salazar

Romania on the path of energy transition - from European projects to citizens' perception **315**
Marinela Istrate

Exploring Local Solutions to Address Energy Access Deficit for Off-grid Communities in Nigeria Through Collaborative Learning **324**
Misbahu Ladan Mohammed, Aminu Bayawa Muhammad, Abdullahi Muhammad Sokoto, Muhammad Saifullahi Ladan and Zaharadden Muhammad Ladan

Methodology to Estimate the Decarbonization Potential at the Neighborhood level. Case study: Benicalap, Valencia, Spain **332**
David Alfonso-Solar, Carlos Vargas-Salgado, Alvaro Manso Burgos, Carla Montagud-Montalvá and Lucía Izquierdo de Andrés

Empowering Sustainable Futures: Integrating Experiential Learning in Energy Education Through LUMS-UoB Exchange Program **340**
Kiran Siraj, Munawwar Ali Abbas, Nauman Zaffar and Naveed Arshad

Enhancing the relevance of vocational training for roofers with the new Sustainable Roofing Methods **350**
Elisa Peñalvo-López, Carla Montagud Montalvá, Vicente León-Martínez and Iván Valencia Salazar

Entrepreneurial Ecosystem in Higher Education: A Systematic Insights for Sustainable Energy Engineering Education at the University of Port Harcourt **359**
Tobinson Briggs and Ogheneruona Diemuodeke

Fostering Sustainable Future: Inter Institute Collaboration, Industry Linkage & Entrepreneurship skills in Higher education **368**
Ale Imran, Mohd Rihan, Jay Prakash Singh and Vikrant Sharma

Guiding Policy Communication: Tailoring Energy Education to Diverse Public Sentiments **378**
Christina Speck, Philipp Fritz, Christof Weinhardt and Jonas Fegert

Crossing Boundaries in Sustainable Energy Education: Transnational Learning is a Two-way Street **387**
Lenny van Onselen, Evelien Ketelaar, Angelique Ruiter, Esther Wijma and Martijn Rietbergen

Collaborative Innovation in Energy: Integrating Design Thinking for Sustainable Product Development **395**
Guilherme Victorino

Sustainable Planning for the Development of Site-Specific Run-Of-River Hydropower: A Case Study in the Gonovo River Catchment, Finschhafen District, Papua New Guinea **403**
Tingneyuc Sekac, Nosare Maika, Sujoy Kumar Jana, Ora Renagi, Sammy Aiau and Dapsy Olatona

Knowledge dissemination and diffusion towards regional ecosystems **413**
Frans van den Akker, Jorrit Bock and Fionna Heuff

Collaborative Reskilling: The Partnership of Hellenic Electricity Distribution Network Operator and University of West Macedonia, Greece, in Advancing Smart Electricity Grids **421**
Evangelos Boutsiadis, Kimon Koulierakis, Dimitrios Tsiamitros, Dimitrios Stimoniaris, Theofano Kollatou, Athina Krestou and Konstantinos Karamarkos

Track 3: Governance & Funding for Sustainable Energy Education

European Initiatives for Professional Excellence in Fossil Free Energy Production 430
Athina Krestou, Alkiviadis Tsamis, Stefanos Gerardis, Stergios Maropoulos, Adam Stimoniaris, Fokion Papathanasiou, Konstantinos Karamarkos, Sofia Papanikolaou, Andreas Maropoulos and Fotios Tsampouris

Techno-Economic Evaluation of Flexible Technologies for Renewable Energy Communities 439
Álvaro Manso Burgos, Isabel Aparisi Cerdá, David Ribó Pérez and Tomas Gomez-Navarro

The comprehensive and unified approach to financing and developing sustainable energy education in Ukraine 447
Halyna Matviienko and Svitlana Kucherkova

Towards Sustainable Academia: Unveiling Trends and Challenges in University Energy Education in Zimbabwe 456
Bright Chisadza and Keith Phiri

Track 4: Sustainable Education

How can we teach sustainability? Active learning based on an experimental game 465
Sabrina Fontanella, Luca Fraccascia, Fabio Nonino and Alessandra Scarnicchia

Beyond Digital Survival… Student Resilience and Acceptance of On-line learning in France 473
Nada Mallah Boustani, Loubna Mourtaji and Nathalie Chiss

Innovating for a sustainable future 483
Mónica María González Cabrera

Field classes in accounting as a "Black Swan" of sustainable education 493
Magdalena Majchrzak and Piotr Szczypa

Education for Sustainable Development in Baltic Universities 501
Dina Bērziņa

Exploring a quantification method of the Whole School Approach with regard to climate action 510
Lena Tholen, Frank Labunski, Oliver Wagner, Maike Venjakob and Sebastian Albert-Seifried

A Study on SDG Awareness in Computer Science Curricula 518
Vicente R. Tomás, Sandra Catalan Pallarés, Mª Isabel Castillo and Germán Léon Navarro

Integrating Service-Learning and Sustainability into the Engineering Curriculum: A Waste Management Case Study 527
María Linares Serrano, Ines Moreno García and M. Isabel Pariente Castilla

Emerging Tech for Future Experts: Unleashing the Potential of Generative AI in Sustainable Education 535
Dragan Vukmirovic, Tijana Comic, Nebojsa Stanojevic and Uros Milicevic

Promoting Energy Sustainability in ICT 543
Consolación Gil, Fernando Martínez, Jorge Ventura, Viktor Isanbaev, Raúl Baños and María G. Montoya

Campus decarbonization challenge learning experience 552
Raquel Martín López, Maria Calero Pastor, Carla de Paredes Gallardo, Hector Espinos Morato, Maria Luz Martínez Musoles and Sofia Garcia Manglano

LLARS application: changing lives from download to download 561
Alba Álvarez Tormos, Joan Aparicio Navarro, Stella Bayona Sedeño, Cristina Catalán Lario, Jesús Comos García, José Manuel Gómez Maestre, Madalina Ionela Grigore, Érica-Alejandra Ivars Bernabeu, Santiago Guillermo Martínez Lozano, Rubén Merino Cantos, Lucia Monzón Barquero, Adriana Moreno González, Javier Navarro Bellver, Luisa Fernanda Robayo Julio, Iris Sánchez Orts, Marcel Sanz Serra, Alba Soler Espí and Silvia Aja Martínez

Learning Cooperations as a Method to integrate Education for Sustainable Development into Further Vocational Education 570
Thomas Spelten, Désirée Rottmann and Semih Severengiz

BIM4CLIMATE: Project-Based Learning to enhance students engineering skills within a CampusLab 580
Blanca Tejedor Herrán, Maria Sande Nogueira Dos Santos Sampaio, Núria Forcada Matheus, Francesc Trisan Segui, Aleix Rifà Beltran, Paula Gordo Gregorio and Marta Gangolells Solanellas

Empowering Amazonian Communities Through Environmental Education and Technology 589
Carme Huguet, Alba Avila and Daniela Alvarez-Gallo

Being effective when talking about Climate Change: an experience from the University of Trento (Italy) **597**
Maria Cantiani

Designing Courses & Increasing Learning Motivation through Gamification **603**
Kim Möller and Thomas Spelten

Implementation of Adaptive Training in Higher Mathematics at Riga Technical University **612**
Inta Volodko and Sarmite Cernajeva

Health Screening & Physical Education Surveillance for Different Types of Students **621**
Florin Mostoflei

Gender equality in the clean energy transition: implementation of an academic toolkit in Bilbao School of Engineering (UPV/EHU) **630**
Saroa Rozas, Natalia Alegría, Saioa Herrero and Paula Serras

Education for sustainability in a secondary and vocational training center **638**
Elisa Adell

Development of a 3D virtual world tool for sustainable energy education **646**
Marta Guerra-Mota, Michalis Xenos, Maria Manuel Sá and Minas Dimosthenis

Empowering SMEs for Business Growth **655**
Anna Ollanketo, Mervi Rajahonka and Heli Saali

What is the best way to communicate with students? An ordered logit regression approach for the study of communication between e-tutors and students in an Italian online University **664**
Giorgio Cecchi, Andrea Nardi and Massimiliano Naldini

Failures of Education Policy Reforms to Address Climate Change **672**
Donal Mulcahy and Judith Madera

Semantic prosody in the field of environment and climate change: a corpus-based analysis **679**
Katrin Herget and Teresa Alegre

OneClickQuiz: Instant GEN AI-Driven Quiz Generation in Moodle **689**
Antoun Yaacoub, Siba Haidar and Jérôme Da Rugna

A Methodological Framework for Survey Design: Investigating Perceptions of Product Sustainability - A Case Study 699
Svenja Hauck, Lucas Greif and Kim Skade

Assessing digitalization in personnel management: a systematic approach and case study 708
Aleksandrs Skvorcovs and Valērijs Dombrovskis

Active Blended Learning of Industry 5.0-Oriented Sustainable Power Engineering Specialists 719
Valery Vodovozov, Zoja Raud and Eduard Petlenkov

Exploring the Affordances of Blockchain Technology to Enable 5R Permissions for Co-Creating OER 726
Bence Lukacs

Environmental Reports of Power Lines: promoting critical awareness about SDGs and professional ethics among engineering students 735
Zaloa Aginako, Rafael Alberdi and Teresa Guraya

Renewable Technologies and Active Learning: Boosting Engineering Education through Student Research Groups 743
Luis Sánchez, Maria Dolores Reyes and Yolanda E-Martín

Scrollytelling as a Strategy for Socio-Environmental Engagement: A Digital Citizen Science Narrative Approach 751
Jorge Sanabria-Z, Inna Artemova, Jesús Gabriel Félix Mendívil and Pamela Geraldine Olivo-Montaño

Watershed and Place-Based Environmental Pedagogies 759
Judith Madera and David Phillips

Reflecting on Addressing Academic Integrity through Authentic Assessment 768
Sharon Lehane and Angela Wright

Sustainable and solidary experiences in our centre 777
Jose Carbonell Alcañiz, Luz Marina Andreu Plaza, Manuel Hurtado Ferrandez, Maria Isabel Rubio Navarro, Maria Luz Rueda Pérez and Rafaela Ferrer Márquez

Embedding sustainability in a hierarchical Higher Education system 785
Paul O'Leary

Emotional Intelligence in Intergenerational Collaboration 793
Juraj Mikuš, Anna Pilková, Miloš Mrva, Jaroslav Huľvej and Yuliia Fedorova

Key factors in the responsible consumption behaviour among university students: The case of Universitat Politècnica de València 802
Mónica Martínez-Gómez, César Berná Escriche and Eliseo Bustamante García

Massive Open Online Courses for Sustainable Urban Development: the RES4CITY approach 810
Álvaro Manso-Burgos, Carla Isabel Montagud Montalvá, Carlos Vargas Salgado, David Alfonso Solar and Rafael Royo Pastor

Assessing Post-pandemic Energy Literacy among Children: Current Concerns and A Predictive Model based on Social Learning Theory 821
Zhichao Lei

#MiSchoolInTransition: learnings from the adaptation of the EuroNet 50/50 method in educational centres of the city of Valencia (Spain) 838
Paula Martin, Blanca Llavata, Paula Martínez, Eduardo Amer and Corentin Girard

The ECF4CLIM Ecological Footprint Calculator as an awareness tool to promote more sustainable behaviors in educational centers 848
Ana Rosa Gamarra Rodríguez, Carmen Lago Rodríguez, Yolanda Lechón Pérez and Isabel Preto

The potential use of infrared cameras to provide a meaningful understanding of thermal science at different levels of education 857
Mar Cañada Soriano, Guillermo Vilariño Feltrer and Rafael Royo Pastor

Living labs and collaborative initiatives on European university campuses for sustainability learning: SusTIMEability-lab project 866
Carla Montagud Montalvá, Javier Sanchis Saez, Javier Soriano Olivares, Ángel Sapena Bañó, Arantxa Querol Monforte and Elisa Peñalvo López

Can AI be used to develop an on demand and sustainable feedback system? 875
Nazim Ali and Sarah Aynsley

Learning sustainable building by doing architectural detail models 884
Elena Montacchini and Angela Lacirignola

Development and sustainment in an Australian education context: Centring Indigenous Knowledges 892
Gabrielle Murray

Principles guiding a South-South capacity development teaching collaboration 899
Monique Keevy

Team projects to promote interest in basic microbiology..... 908
Linda Mezule

An activity to promote entrepreneurship and sustainable tourism business models for undergraduate students.....914
Vicent Caballer-Tarazona and Maria Caballer-Tarazona

Pedal for your future 919
Nuria Arenas Peiró and Susana Martí Sendra

Changing individuals, institutions and environmental conditions: an innovative hybrid participatory approach for sustainability in education.....927
Yolanda Lechón, Ana Prades, Silvia German, Josep Espluga, Markku Lehtonen, Jose Antonio Becerra, Israel Marques, Terhi Nokkala, Hannu Heikkinen, Anna Lehtonen, Niina Mykrä, Ricardo Chacartegui and Ana Rosa Gamarra

Designing a Massive Open Online Courses (MOOC) for Effective Learning in Electrical Energy Economics and Planning for Engineering Students 936
Nofri Yenita Dahlan and Jefri Dahlan

Institutional Policies and Higher Education in Sustainability Agenda.....945
Nikolaos Taousanidis and Andreas Taousanidis

Sustaining Authentic Assessment (AA): A pilot survey of student perceptions of AA to improve higher order thinking and employability 952
Judy Rose and Adis Duderija

A study of problem-based learning in higher education with a focus on sustainability degree programmes 961
Semih Severengiz, Stephan Sommer, Michelle Hoffmann and Ann Kathrin Stinder

Sustainable Education for Business Leaders: Integrating Corporate Social Responsibility (CSR) and Environmental, Social, and Corporate Governance (ESG) in MBA Programs – A Vietnamese Perspective.....970
Lorena Mathien

Engaging students in Circular Design: teaching experiences with (future) architects and designers.....979
Silvia Tedesco, Elena Montacchini and Nicolò Di Prima

Sustainable Education in Art and Design Universities: A Teaching Case Emphasizing Materials 988
Ziyu Zhou, Anna Palm and Markus Holzbach

Agroecology and energy sustainability at the IES "Las Norias": A solidarity project for the most vulnerable families

Cristóbal Sánchez Lozano, Gabriel Giménez Cisilino, Rubén José Ferrández Ballester

IES "Las Norias". Conselleria de Educación, Universidades y Empleo. Generalitat Valenciana. España.

Abstract

The IES "Las Norias" in Monforte del Cid (Alicante) teaches basic degree training cycles in Agrogardening and Floral Compositions, intermediate degree in Agroecological Production and higher degree in Renewable Energies. It has signed an agreement with the company Suelos y Promociones Caiba S.L. for the transfer of the use of a plot of land adjacent to the center. so that students can carry out organic farming practices.

The irrigation water is supplied by the Irrigation Community of Monforte del Cid, and it will be stored in two 5000l water tanks which will be installed in the plot, where vegetables will be grown. The collected production will be allocated to the most economically vulnerable families in the municipality, with the control of the Municipal Social Services and direct distribution from the charity Cáritas.

Likewise, the IES "Las Norias" will launch a photovoltaic installation to supply renewable energy to both the basic degree vocational training classrooms and the entire automation of the greenhouse. Thus, the young plants will be initially grown within the greenhouse and will be planted on the plot further on.

In this way we intend to add the technical knowledge of the students and teachers of the Agrarian and Energy professional families, for ecological agricultural production and to help the most economically vulnerable families of Monforte del Cid in their most basic need: food.

Keywords: Agroecology, Organic agriculture, Renewable energies, Sustainability, Social economy.

How to cite: Sánchez Lozano, C.; Giménez Cisilino, G.; Ferrández Ballester, R.J. (2024) Agroecology and energy sustainability at the IES "Las Norias": A solidarity project for the most vulnerable families. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 1-8.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The IES "Las Norias" has been teaching the FPB Agrogardening and Floral Compositions cycle since the 2014-2015 academic year. In the 2022-2023 academic year, it began to teach the higher-level training cycle in Renewable Energies, and in the 2023-2024 academic year, the intermediate-level training cycle in Agroecological Production. The center does not have space available to create a small agricultural farm, so the center's management initiated contacts with the owners of plots of land near the institute to be able to use them as an internship space for students.

In November 2023 we contacted the company Suelos y Promociones Caiba S.L. It is a developer and construction company with different real estate projects currently underway in several municipalities in the province of Alicante, and owner of a 4,500 m² plot located next to the IES "Las Norias", which has been unbuilt and unused for several years.

The company gave the use of the plot of land to the center for use as an ecological garden free of charge, as long as it was not needed for construction or sale. On December 1, an agreement was signed so that said transfer was legally supported and a report was also required from the Faculty and the School Council, which were favorable in both cases. This agreement came into force on January 1, 2024.

The donated land will be used for the cultivation of seasonal vegetables using organic farming techniques. Likewise, the IES "Las Norias" is authorized to fence the site to guarantee adequate protection of the crop, prevent theft or acts of vandalism and to carry out drip irrigation installations or any other technique that makes sustainable use of water. with all the necessary elements (house, fertilizer spreader, pipes, cutting keys...). The harvest will be given to the poorest families in Monforte

The IES "Las Norias" has installed a 60 m² automated greenhouse, in which indoor crops will be grown. A nursery will be installed to later move the plants to said site. It is also the intention of the center to carry out a photovoltaic installation to supply the classrooms in which Basic Vocational Training is taught and the greenhouse. We intend to involve the teachers and students of the professional family of Energy as well as raise awareness among our students that teaching activities can be carried out only with renewable energy.

On the other hand, conversations have also begun with the Monforte del Cid City Council, the Irrigation Local Community and with the local charity Cáritas to ask them to collaborate in this project in the following way:

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- The Irrigation Community of Monforte del Cid will provide the drip irrigation water, which will be stored in two 5000l water tanks. The cost of water will be taken on by the Monforte del City Council and the agricultural production that is collected will be allocated to the most in need families in the municipality.
- The City Council will determine which families will benefit from this help.
- Finally, Cáritas will oversee effectively distributing agricultural production to the poorest families who have been previously referred by the Municipal Social Services.

This project begins its journey in January 2024 and we intend to develop it indefinitely as long as we can use the transferred plot. Our main objectives are:

- Take advantage of the technical knowledge of the Agrarian and Energy professional families.
- Mobilize public and private entities in the municipality.
- Raise awareness among our students and teachers about the sustainability of production systems, both energy and food.
- Promote the social economy (Salinas, F et al., 2022) by putting all that knowledge and enthusiasm to be part of this project, at the service of the poorest families in the municipality (United Nations, 2014.).

Therewith, we contribute to the following sustainable development objectives (CEPES España, 2019).

- Eradicate poverty and hunger by giving food to the most disadvantaged families.
- Improve food security, since all agricultural production is grown using organic farming techniques.
- Promote sustainable agriculture, since the soil and production are not contaminated with chemicals and rational use of water is made.
- Produce non-polluting energy that will supply electricity to the Basic Vocational Training classrooms and the greenhouse.

2. Our photovoltaic installation

With the implementation of this project, the goal is for the students of the higher degree in Renewable Energy to be able to put into practice the acquired knowledge.

On a first stage, a theoretical and technical study will be carried out to analyze the needs of both the greenhouse and the building where the Agrarian vocational training classes are held to meet their energy needs. Besides, they will have to provide a solution to the problem, which needs to be feasible, implementable, economically viable, and then brought to reality.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

In the experience with our students, two main behaviors are noticed. There is a group who has a vocation to carry out more design and consulting work and others who have a more practical vocation and are attracted to more instrumental activities.

This experience will allow everyone to expand and test their knowledge and skills, as well as allow them to learn first-hand about the complications that each phase of the design and implementation of the solution has. This, which may seem trivial, is not. In their work performance, our students will have to work cooperatively in working teams. Bad or inefficient communication is a common problem when working in teams. The mere ability to be able to coordinate and direct work teams is an important skill, and this project will provide our students with this experience, which is very difficult to teach and transmit in the classroom.

The steps that our students will have to follow to solve the project will be the following ones:

- Collaborate with the Agrarian group so as to identify their energy needs. Students will arrange a meeting with those responsible for the Agrarian department to analyze their energy consumption and the best location for the installation.
- Study and quantification of the energy needs: once the needs are understood, they must be quantified. They will have to quantify the electrical consumption of the current building and estimate those of the future greenhouse. Here you can use the methods explained in the book "Configuration of photovoltaic solar installations" studied in class. They should also check their estimates, to the extent possible, with measurements of actual consumption that can obtained.
- Propose actions on energy efficiency: The facilities currently used use fluorescent lighting. They must quantify the energy savings that switching to more modern lighting would make.
- Determine the location of the installation: They will have to choose a specific location for the equipment. Likewise, they must decide the routes that the electrical conduits should take. Since it is a real installation, there will be several possible viable solutions, all with their pros and cons.
- Calculate the photovoltaic power that can be installed. Within the selected surface they must calculate the power in panels that they can install. To do this, they must use the studied methods.
- Carry out the calculation of shadows and energy produced. They will have to use the knowledge acquired in the classroom for the calculation of shadows and of the energy produced by the panels, for their different inclinations and orientations (Cantos, 2022).
- Sizing of the photovoltaic installation. At this point, students will have to decide the size of the installation and its configuration: number of panels, string number, inverter power.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- Design of the electrical installation. They may decide the route that the installation wiring would follow by sizing the electrical protections, selecting the conduits and sizing the wiring to comply with the current legal framework in force (*Real Decreto 842/2002 de 2 de agosto, BOE de 18-09-2002).*
- The installation process. Students might have to face some issues throughout this phase: from organizing a temporary warehouse for the material, to managing delays in the material delivery and planning the activities.

Students will have to manage the use of material to which they are not accustomed, such as the use of the lifting platform or the installation of safety measures for working at height.

3. Our solidarity garden. An agroecological, sustainable and social plot

The plot is located a few meters away from the high school, what makes the organization of tasks and the movement of students and resources easier. There is an area of about half a hectare whose soil seems to have a clay-loam texture. Likewise, the plot has good quality water resources, something that facilitates the implementation of highly efficient localized irrigation systems. To make the agreement visible and publicize it, there will be informative and accessible signage.

The close collaboration between the Agrarian and Energy department makes possible to work in harmony from two different perspectives: the production of organic crops from an agroecological vision, as well as the search for sustainable energy efficiency of certain agricultural facilities.

At the same time, the synergy resulting from this association has the ultimate purpose of contributing to local development, with the harvest obtained being given to the poorest families in the town. The distribution of food is intended to be carried out thanks to the involvement of the Local Social Services and Cáritas.

4. Workplan

The Agrarian Department is committed to transforming this new plot into an agroecological beacon (Altieri, 2001) that encourages demonstration, education and training, from the practical and local perspective, with a social perspective.

As this is a long-term project, a work schedule has been designed for 2024 After the first phase, that of preparation of the necessary elements, we will start the production in September 2024 according to the following work plan.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1 – Work plan

ACTION	EXPECTED DATE
Agreements between the collaborative bodies: City Council and Cáritas.	February 2024
Meetings between the students of the Energy Family and the Agriculture department to determine the energy needs.	February 2024
Determine the size of the photovoltaic installation.	February 2024
Preparation of the plot; soil clearing and decompression work.	March 2024
Clearing the land and distribution of cultivable spaces.	March 2024
Study and design of the irrigation system and fertilization programme.	March 2024
Design and planning of crop rotation.	March 2024
Fencing the plot.	April 2024
Installation of water tanks and pumping house.	April 2024
Implementation of the photovoltaic installation.	May 2024
Distribution of the main tubes of the irrigation system and shut-off valves.	June 2024
Installation of Informative posters.	June 2024
Planting the arable area and running the crop.	September 2024
Reaping the crop and distributing it through social agents.	December 2024
Dissemination of the experience (Webpage, TV, local radio, congresses, etc)	December 2024

Source: Own elaboration

In the previous working plan the students of the Higher Degree of Energy will be in charge of designing, seizing and implementing the photovoltaic installation which will provide energy to the rooms of Basic Vocational Training and the Greenhouse.

Likewise, students of the Basic and Medium Agricultural Intermediate degree will take on the preparation of the soil, design of the planting, crop rotation, irrigation. They will also take care of the plot three times a week (Mondays, Wednesdays and Fridays at school times) until reaping the crop.

Finally, the students of the Agrarian family will deliver the harvest to Cáritas for them to distribute it among the families who might need it (following the criteria set by the Local Social Services).

It is our intention to keep this project as long as we are able to farm the plot and grow vegetables to be given to the poorest families in Monforte. Furthermore, we want to

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

offerour current and future students of the Agricultural and Renewable Energy degrees the possibility of working together for applying their classroom knowledge to take part in a charity project that helps the most vulnerable families in the town.

Fig. 1 – Location plan



Source: Own elaboration

Acknowledgements

We are willing to express our gratitude to the organizations that have made this project possible

To the enterprise Suelos and Promociones Caliba S.L. for transferring their plot to IES "Las Norias". Thanks to them, our students have been able to carry out their internships and this project has been feasible.

To Monforte del Cid's Irrigation Association for giving us sustainable water for our crops.

To Monforte del Cid's City Council for providing the list of the local cities that would benefit from this initiative.

To Cáritas, whose participation has been essential to make possible the food distribution among the families in need.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conflicts of interest

The authors declare that they have no competing financial interests or personal relationships that could have influenced the work presented in this article.

Bibliographic references

Altieri M.A., Rosset P.M. (2018). Agroecología. Ciencia y política. Icaria Editorial.

CEPES España (2019). La contribución de la Economía Social a los Objetivos de Desarrollo Sostenible. España, CEPES-España.

Cantos Serrano, J. (2022). Configuración de instalaciones solares fotovoltaicas.

Instituto para la diversificación y ahorro de la energía (2011) Pliego de Condiciones Técnicas de Instalaciones Conectadas a Red.

Labrador J. (2016). Educar en agroecología en el contexto de la educación superior. Una invitación a la reflexión. Agroecología, 11(1), 63-74. http://hdl.handle.net/10201/58142

NACIONES UNIDAS (2014). La Economía Social y Solidaria y el Reto del Desarrollo Sostenible. Suiza, TFSSE.

NACIONES UNIDAS (2018). Social and Solidarity Economy for the Sustainable Development Goals. Suiza, UNRISD.

Real Decreto 842/2002 de 2 de agosto por el que se aprueba el Reglamento Electrotécnico para Baja Tensión. BOE de 18-09-2002.

Salinas, F, Jorge-Vázquez, J, Muñoz, N Del Nogal (2022). La Economía Social ante los Objetivos de Desarrollo Sostenible de la Agenda 2030. https://ciriec.es/?descargar-publicacion=3728&view=1

Sevilla E. (2007). De la sociología rural a la agroecología. Icaria Editorial.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Using heat-loss in buildings as a concept to foster sustainability and systems thinking in students

Lorenzo Galante[a], Irina Mancheva[b], Stefano Fantucci[c] and Valentina Serra[c]

[a]Teaching and Language Lab, Politecnico di Torino, Italy

[b]Department of Political Science, Umeå University, Sweden

[c]Department of Energy , Politecnico di Torino, Italy

Abstract

In the framework of the EU Erasmus+ Blended Intensive Programme (BIP), a new multidisciplinary course *"Heat loss in buildings and sustainability: local approaches to global problems"* was designed and implemented in collaboration between three European universities. The aim was to introduce engineering and architecture students to sustainability and systems thinking in relation to energy use in buildings. Together with conventional lecturing and seminars, a mixture of online, in-person, theoretical and unconventional hands-on teaching methods and activities was applied, including, lectures, discussion seminars, experiments and a role-play. This approach required the strong involvement and collaboration of the teaching staff, who, by combining different disciplines and collaborating across universities and national boundaries, acquired invaluable pedagogical experience. Most importantly, students from different countries and disciplinary backgrounds were exposed to a mixture of subjects that they might not otherwise have experienced in their engineering and architecture programmes, i.e., policy and governance, physics, and energy systems. In this way, the course laid the foundations for systems thinking and a sustainability mindset.

Keywords: heat-loss; energy in buildings; governance; sustainability education; learning-by-doing.

How to cite: Galante, L; Mancheva, I, Fantucci, S and Serra, V (2024) Using heat-loss in buildings as a concept to foster sustainability and systems thinking in students. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 9-17. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

For society to achieve the United Nations Sustainable Development Goals (UN SDGs), key competencies such as systems and critical thinking, problem solving, self-awareness and collaboration must be fostered through education (Rieckmann, 2017). A multidisciplinary course "*Heat loss in buildings and sustainability: local approaches to global problems*" was developed, aiming to introduce a systems thinking and sustainability mindset to students in engineering and architecture. The 3 ECTS (European Credit Transfer and Accumulation System) course was hosted by Politecnico di Torino. It was designed as a blended intensive programme (BIP) in collaboration with Umeå University and Universitat Politècnica de Catalunya. The interactive part of the course lasted two weeks, and the students had an additional three weeks for submitting the final examination.

Since the course was mainly aimed towards bachelor students in engineering or architecture, it included very few requirements for prior knowledge. Instead, to reach a better and deeper understanding of energy dilemmas, all the basic concepts necessary to understand the principles of heat loss through the building envelopes were presented through both a simplified theoretical approach and easy hands-on experiments (learning-by-doing approach). The course also included theoretical online and in-person lectures and a practice-oriented role-play on governance and policymaking at European Union (EU) level. Finally, in order to expand the picture on current energy research, the course included visits to the HySyLab and CO_2 Circle Lab integrated facilities, that are aimed at exploring and testing H_2 and CO_2 processes and technologies.

By combining theoretical sessions with practical exercises from various research fields, the course had the ambition to communicate a holistic approach to energy sustainability and thus foster critical thinking and creativity on issues ranging from the energy performance of buildings, different methods to mitigate thermal transmittance, and multilevel governance strategies to achieving sustainability goals. As a result, the students became familiar with the main aspects related to the UN SDGs and were exposed to an analysis of complex systems through simple experiments, calculations and reflections based on small-scale models, forcing them to think at different scales and recognize the uncertainty behind potential solutions. The social and experimental events, and the many discussions with fellow students and the course teachers further developed students' collaboration skills through learning from others and respecting each other's needs, perspectives and actions.

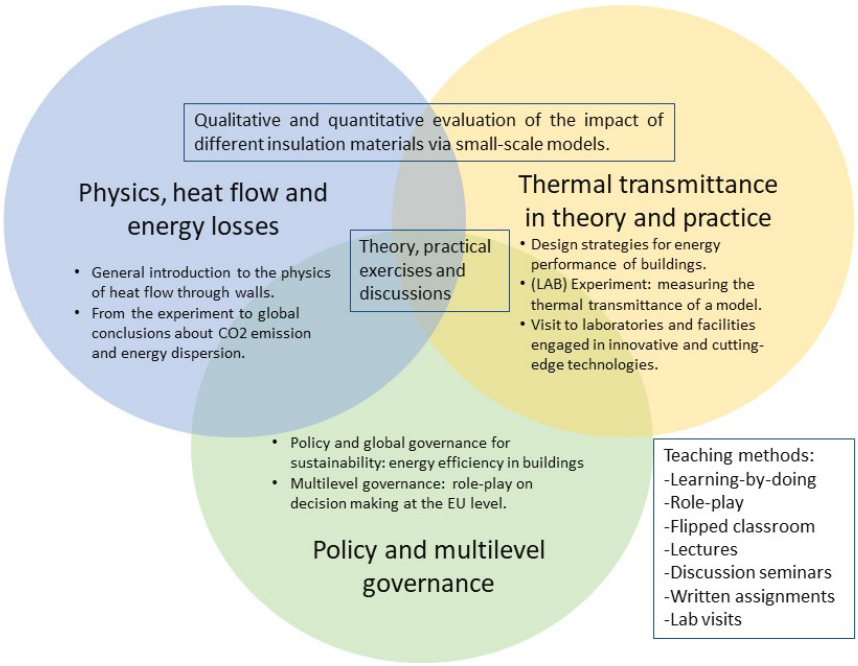
2. Design and teaching methods

The course consisted of three main themes: 1) Physics, heat flow and energy losses, 2) Thermal transmittance in theory and practice and 3) Policy and multilevel governance for sustainability; and eight subthemes, some transcending over several main themes (see Fig.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

1). A mixture of teaching methods was used (Fig. 2), including lectures, seminars with discussions, lab demonstrations and experiments, the construction of a small-scale simplified building models with a 3D printed box made of PLA (one of the most used polymers for additive manufacturing), individual and group written assignments, as well as a role-play focusing on EU decision-making. The course was constantly evaluated and revised (Roxå and Mårtensson, 2011) by asking students to fill in daily anonymous online evaluation surveys.

Fig. 1 – Main themes, subthemes and teaching methods



Source: Own elaboration

Inquiry-based learning was integrated in two parts of the course. First, students carried out a very simple and low-cost experiment (the cooling process of two differently insulated cans) in the very beginning during a special welcome party called "Fluococktail-Thermal party" (Fig. 2). The second inquiry-based activity was part of the thermal transmittance theme and included the measurement of the transmittance of a 3D-printed cubic box insulated with different materials and thicknesses (Fig. 3). These experiments helped students to acquire a deep understanding of the physical processes involved in energy loss in buildings and of the effects of different insulation solutions. Problem-based learning (Yew and Goh, 2016) was incorporated by asking the students to apply what they have learned to a typical building of the hosting city, Turin (Italy). Starting with a single building, they scaled up to the size of the city, estimating the order of magnitude of the winter heat loss in a northern Italian city and tried to figure out whether the photovoltaic solution, combined with a heat pump, would completely cover the buildings heat demand in winter. Problem-based learning was also used in the policy and multilevel governance theme through a scenario discussion in the virtual session and a task during the in-person day. The task required students to update the EU

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Energy Performance of buildings Directive while representing various EU institutions, i.e., the European Commission, the European Parliament and the Council of Ministers.

Fig.2 – A mixture of teaching methods was applied: hands-on experiments, lectures, lab visits, and informal learning like the "Fluococktail-thermal party"



Source: Own elaboration

"Flipped classroom" strategies (O'Flaherty and Philips, 2015) were applied in several parts of the course, asking students to find and summarize information individually or in groups, presenting their findings to the whole group or by submitting a report. This mixture of teaching methods aimed at enabling students to familiarize themselves with the main concepts, while also engaging in discussions and taking part in the reflections of others. The one-way communication that a lecture entails was thus broken down into smaller blocks, contributing to a more dynamic learning environment (Bain, 2004). Depending on the learning objectives of the course and the teaching activities connected to them, students' learning was assessed in various ways (Edström, 2008).

3. Implementation and results

3.1. Physics, heat flow and energy losses

The introduction of a few basic physical quantities and little mathematics are, together with openness to reflection, the ingredients for achieving awareness on the impact at a global level of the energy demand for heating and cooling in buildings. In the EU these demands are responsible for 40% of the energy consumption and 36% of greenhouse gas emissions (EC, 2022). Focusing on this issue with students who are the future city planners, architects and engineers, can prove valuable and contribute to form a sustainability mindset. Following this line of thought, a few fundamental quantities were presented from the beginning of the course (Table 1) and their physical meaning was explained in depth. These efforts paid off, since all students responded positively in the online anonymous survey, with one example

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

being: "*I have difficulty with equations but the close interaction with the teachers made it easier to understand and to be able to do the exercises and understand the reason behind doing it.*"

Once this basic knowledge was acquired, students were immediately challenged with a problem solving activity. They were asked to reflect on a simplified building (a 10m-side cube) with a 100 m² roof entirely covered with photovoltaic panels that are combined with a heat pump to cover the heating demand of the building. The walls could be of three different materials whose thermal conductivity is well known. According to the chosen material, the students had to estimate the correct thickness of the walls to maintain a temperature difference of 20 K between the inside and the outside of the building, only counting on the energy provided by the photovoltaic system. They were told that this is a typical situation in Turin during the winter season. Once they shared and discussed the results, they were asked to scale to the entire city (nearly 1 million inhabitants) and to estimate the order of magnitude of the power loss related to the buildings' heating in Turin during the winter season.

Table 1 – List of the fundamental physical quantities presented in the course

Quantity	Units
Heat Flow density **q**	W/m²
Thermal Conductivity **λ**	W/ (m K)
Heat Flow **Φ**	W
Thermal Conductance **C**	W / (m² K)
Thermal Transmittance **U** (U-value)	W / (m² K)

Source: Own elaboration

3.2. Thermal transmittance in theory and practice with a laboratory experiment

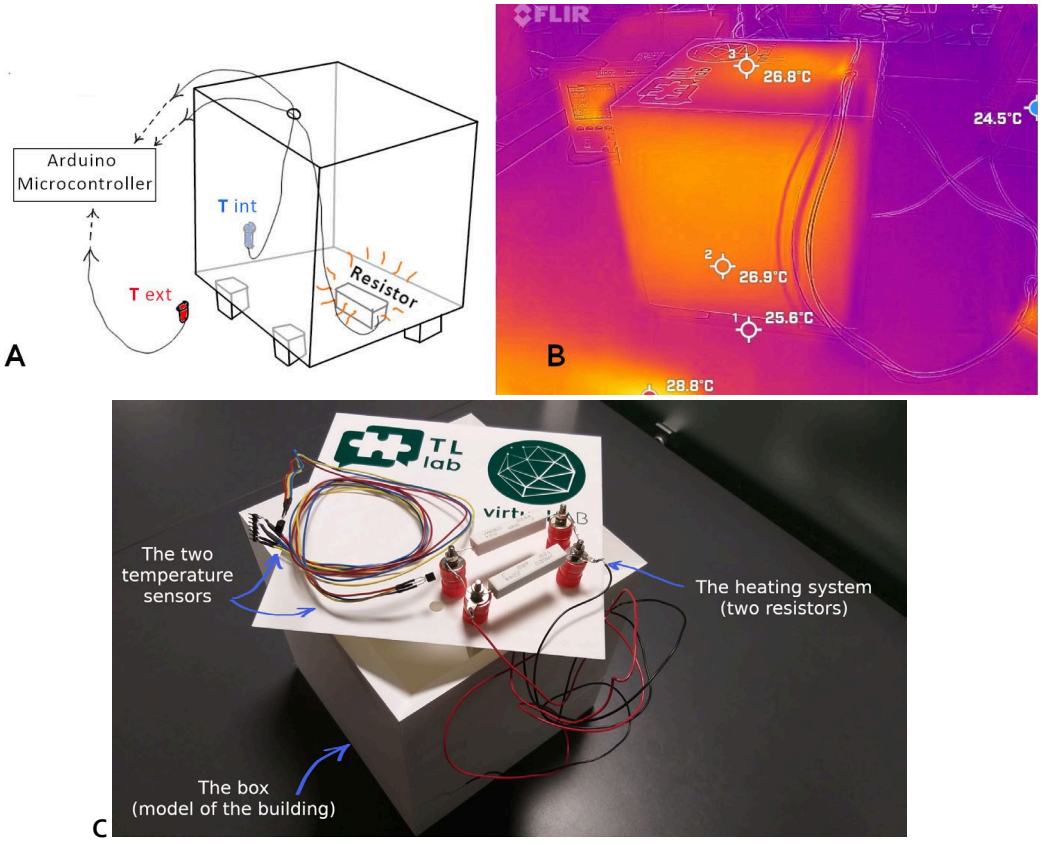
A 3D-printed box was used as a simplified building model for students to experiment with the concept of Thermal Transmittance (U-Value) of the building envelope. The basic idea was to control (through an Arduino Microcontroller) a resistor (our *heating system*), placed inside the box, to keep a constant temperature difference Δ**T** between the inside and the outside of the box. The resistor heats the internal volume dissipating a known electrical power and can be turned on or off by the Arduino micro-controller. Two sensors measured the internal and external temperature vs. Time (Fig. 3A, C). With this data, knowing the total surface of the box, students could estimate the average **U-value** of the envelope of the building model.

Students worked with three different insulating configurations (Table 2). During the activity, they were encouraged to discuss their expectations for the reduction or increase of the U-Value of the box with different insulation. The day after the lab activity, the groups discussed the measured U-values and the experimental results were compared with the theoretical expectations, allowing the main reasons for the change in Transmittance to be identified. The

BY-NC-SA 2024, Editorial Universitat Politècnica de València

U-values of the five groups for the three configurations are plotted in figures 4A, 4B, 5. Students took pictures of the box with a low-cost portable smartphone-connected Infrared camera (FLIR-one) to directly visualize the effect of the heat losses (Fig. 3B).

Fig. 3 – A: The general sketch of the 3D-printed Box and the experimental apparatus to measure the U-value of the building model. B: The Infrared image of a box while heated from the inside with the resistors. C: Main parts of the apparatus the students worked with.



Source: Own elaboration

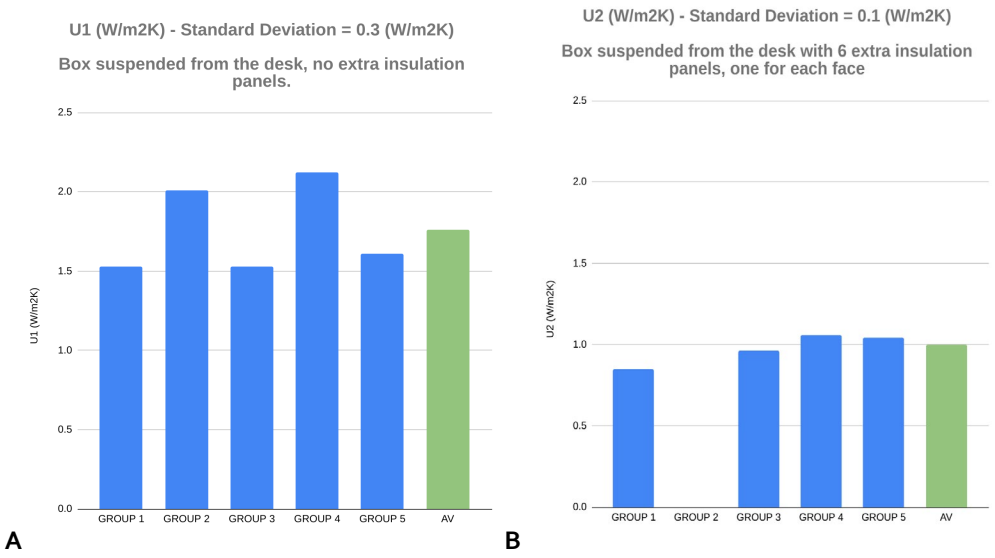
Table 2 – Different insulating configurations of the box

Configuration	Insulation
1	Just the box suspended from the desk.
2	Config. 1 plus one extra polystyrene panel (thickness 2cm) for each face of the cube.
3	Config. 2 plus an aluminum foil covering all the internal walls.

Source: Own elaboration

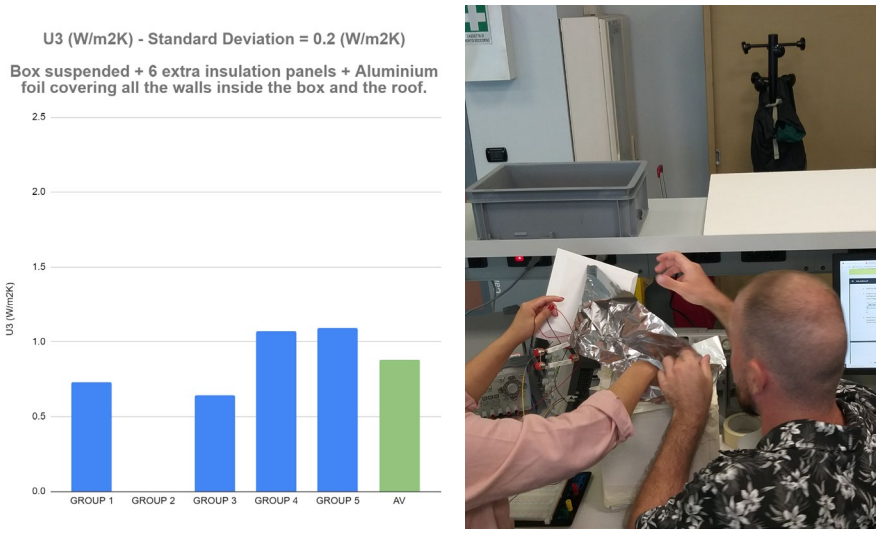
 BY-NC-SA

Fig. 4A – U-values estimated by each group for the config. 1. In green the average value. B – U-values for the config. 2 (polystyrene panels, thickness = 2 cm). (Group 2 added only 5 extra panels therefore is not considered in the chart)



Source: Own elaboration

Fig. 5 – U-values for the config. 3 (internal Aluminium foil). In green the average value.



Source: Own elaboration

3.3. Policy and multilevel governance for sustainability

The policy and multilevel governance theme included one virtual and one in-person day. The virtual day included a lecture on Global Environmental Governance that aimed to introduce the basics and a background on the complexity of multilevel policymaking. The lecture was followed by a practical online seminar, where the students, according to the "flipped classroom" method, first had to prepare by reading several chapters and research articles and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

then discuss a given scenario in the afternoon. During the in-person day, a mixture of different activities was organized: some teacher-led, others autonomous student activities. The day was finished off with a role-play mimicking the ordinary decision-making procedure at EU level. By focusing on a concrete problem: energy efficiency of buildings in a multilevel governance context, the role-play aimed to increase the participants' understanding on how decisions are made at the EU level, but also how different actors (e.g., citizens, researchers, experts, companies) can influence the positions of various EU institutions and member states. The students were divided into three groups representing the European Commission, the European Parliament and the Council of the European Union. In the latter two groups, each student represented a political party or EU member state respectively. Before the role-play, the students had to familiarize themselves with the EU Energy Performance of buildings Directive and prepare their stance on its revision both individually and within their designated group. During the role-play, each student in turn presented and reasoned for the position they had prepared according to the institution, political party or country they represented. The students then voted in turn for the proposed changes in several rounds, following the ordinary EU decision-making procedure and ended the session with a group discussion.

The mixture of activities was appreciated by the students, and they participated actively. The discrepancy between the background knowledge of the students on policy, politics and aspects of governance, together with the mixture of country backgrounds, allowed for vivid discussions and personal examples of governance failures and successes. The learning potential of the role-play was especially appreciated, with some of the responses to the online anonymous evaluation stating: *"(…) interesting learning experience"* and *"I always wanted to do a roleplay for debating issues, it was great and a fun experience to learn."*

4. Discussion based on the experience from the course

Working together with colleagues from different disciplines, universities and countries in designing and implementing this course, and interacting with students with different nationalities and disciplinary backgrounds (i.e. architecture, civil, environmental, electronic and energy engineering) has been an enlightening endeavour. It allowed the staff to develop their pedagogical skills by exposing them to subjects and teaching methods that they do not apply in their usual teaching practice. Most importantly, by introducing students to peers from other programmes and countries, the multidisciplinary course has exposed them to the challenges and opportunities in achieving energy sustainability.

Each step of the creation and implementation of the multidisciplinary course "*Heat loss in buildings and sustainability: local approaches to global problems*", from the design to the planning, execution and evaluation, helped the teaching staff to gather valuable pedagogical and practical insights and experiences. Starting with the design, it took a significant amount

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

of time to both find collaborators willing to invest efforts in developing the course, but also to coordinate between the researchers and the administrative entities of the three partnering universities. However, both the teaching staff and the students gathered invaluable knowledge in multiple disciplines and collaborative experience, pointing to the importance of investment in student internationalization and administrative support from international organizations and university bodies (e.g., the EU Erasmus+ BIP funding).

Acknowledgements

The visiting teachers' travel costs were covered by Erasmus+. Other costs, mainly for the experiments, were covered by Politecnico di Torino staff involved in the course and coming from personal funding the Institution provides for research and teaching purposes (RBA). The Swedish Research Council Grant 2020-06415 supported IM. A special thanks to Ivan Gnesi, Mariana Palumbo and Piergiorgio Rossi for helping design and implement the course, as well as to the dedicated International Office and faculty staff of the three universities. We are grateful to the four anonymous reviewers for their feedback.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bain, K. (2004). What makes great teachers great." *Chronicle of Higher Education* 50, no. 31: B7-B9.

Edström, K. (2008). Doing course evaluation as if learning matters most. *Higher education research & development*, *27*(2), 95-106.

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: A scoping review. *The internet and higher education*, *25*, 85-95.

Rieckmann, M. (2017). *Education for sustainable development goals: Learning objectives*. UNESCO publishing.

Roxå, T., & Mårtensson, K. (2011). Improving university teaching through student feedback: a critical investigation. In *Student Feedback* (pp. 61-79). Chandos Publishing.

Yew, E. H., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health professions education*, *2*(2), 75-79.

European Commission (2022), Directorate-General for Energy, Gerard, F., Smit, T., Rademaekers, K. et al., Policy support for heating and cooling decarbonisation – Roadmap, Publications Office of the European Union, https://data.europa.eu/doi/10.2833/977806

Course website: https://www.polito.it/en/polito/international-campus/international-course-catalogue/erasmus-bip/heat-loss-in-buildings-and-sustainability-local-approaches

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Analysis of the contribution to sustainable energy training of the degrees taught at the ETSII of the UPV

José F. Villanueva[a], Ana Vallés[b], Andrés Lapuebla[c], Ana Esteso[d], Sergio Gallardo[a], María Sancho[a] and Angel Ortíz[d]

[a]Department of Chemical and Nuclear Engineering, Universitat Politècnica de València, Spain
[b]Department of Applied Thermodynamics, Universitat Politècnica de València, Spain
[c]Department of Mechanics of Continuous Media and Theory of Structures, Universitat Politècnica de València, Spain
[d]Department of Business Organisation, Universitat Politècnica de València, Spain

Abstract

This paper presents the ongoing project at the Technical School of Industrial Engineering (ETSII) aimed to incorporate Sustainable Development Goals (SDGs) into the academic curricula. The primary objective of this work is to assess the current state of SDG training at ETSII and develop a training itinerary for effective integration in subjects whose contents are related to sustainable energy. The research methodology involved reviewing Teaching Guides and conducting surveys among students and teachers to gather insights on their awareness and training in SDGs. Seven out of fifteen degrees at ETSII are directly aligned with sustainable energy topics, contributing to SDGs 7, 9, 12, and 13. The findings highlight the potential impact on a significant number of students and teachers. It is believed that integrating SDGs into the curriculum will enhance students' understanding of sustainable development and equip them with the necessary skills to address global challenges. The project showcases the institution's commitment to SDGs and the 2030 Agenda. The next steps involve defining the future state and implementing the training itinerary. This initiative aims to empower students, enabling them for a more sustainable future.

Keywords: sustainable energy; industrial engineering; teaching guide; online survey.

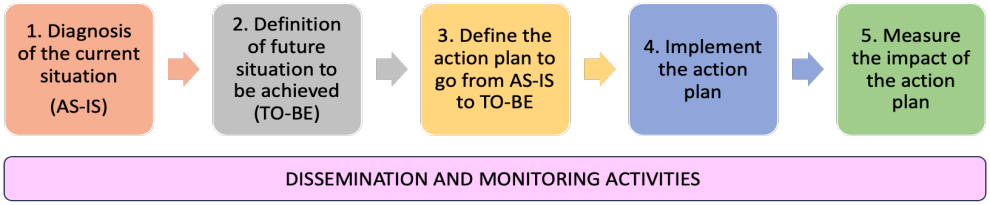
How to cite: Villanueva, J.; Vallés, A.; Lapuebla, A.; Esteso, A.; Gallardo, S.; Sancho, M. and Ortíz, A. (2024) Analysis of the contribution to sustainable energy training of the degrees taught at the ETSII of the UPV. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 18-24.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The Sustainable Development Goals (SDGs) have inspired global actions. Many initiatives, alliances and networks have been undertaken in order to promote its achievement. To the consensus existing in the United Nations (UN) and national governments (G20 Action Plan; Voluntary National Reviews), it was added the growing interest of companies (CEO Statement of Continued Support for SDGs) and universities, which play a key role in the implementation of the 2030 Agenda and the achievement of the 17 SDGs. This is reflected in the recent RD 822/2021 (Boletín Oficial del Estado nº 233), which establishes the organization of higher education and encouraging the training in SDGs at all educational levels. Given this situation, the Technical School of Industrial Engineering (ETSII) of the Universitat Politècnica de València (UPV) requested an Institutional Educational Innovation and Improvement Project (PIME) in 2021 with the main objective of developing actions that contribute to the achievement of the SDGs in all degrees taught at the school. The PIME was structured in several sequential phases, as seen in Fig. 1.

Figure 1. Sequential diagram of the SDG training PIME project.



Source: Own elaboration

The first stage of the PIME, now completed, diagnosed the current situation (AS-IS) to know what the initial situation of the ETSII was regarding training in the SDGs, answering questions about the level of knowledge of students and teachers about the SDGs and which of them were worked on in the degrees. Through the second stage (in development) the future situation wanted to be achieved (TO-BE) will be defined, trying to answer questions such as: what SDGs are wanted to be integrated into the studies. In the third stage, to be developed during this 2023-24 academic year, an attempt will be made to define a training itinerary that includes a methodological route to go from the current (AS-IS) to the future state (TO-BE), including definition of activities in subjects, final Degree and Master theses, among others. The fourth stage will consist of implementing the previously defined training itinerary; and in the last and fifth stage the impact of the PIME on the ETSII degrees will be measured. With all these actions, it is pursued a progressive integration of the SDGs in the training of our students, which will subsequently contribute to their achievement once, as graduates, they enter the world of work. Given that the ETSII currently has 15 official degrees (5 Degrees, a double Degree and 9 Masters, 2 of them qualifying), the PIME has a high potential to impact

BY-NC-SA 2024, Editorial Universitat Politècnica de València

more than 4000 enrolled students, and more than 600 teachers from 26 different departments.

2. Methodology

This work focuses on the first diagnostic stage and is based on the following tasks carried out:

a) **Review of the Teaching Guides of all the core subjects of the School.** To this end, work groups were formed by degree, made up of PIME participants with teaching in the corresponding degree. These groups reviewed the Teaching Guides and collected the information related to SDG training in a Microsoft Excel template that included both data on the training at the time of the review and data on the SDG training potential of the subject (Vallés-Lluch et al., 2022) (Villanueva et al., 2022).
b) **Surveys on SDGs pass to students and teachers.** Surveys were developed based on the indicators selected after an extensive bibliographic search, and these surveys were structured in two different parts: one on general knowledge and awareness of the SDGs (Esteso et al., 2023), whose results have not yet been processed; and another related to training in SDGs in the subjects taken (students survey) or taught (teacher survey) (Martínez-Gómez et al., 2023).

Based on the information collected with these two tasks, reports were prepared that summarized the main results for each of the ETSII degrees, including the most appropriate SDG training itinerary proposal in each case.

2.1 Methodology to identify training in sustainable energy.

To delve into the assessment of training programs in sustainable energy, we've chosen specific SDGs and their associated targets. Naturally, our primary focus is on SDG 7, *Affordable and Clean Energy*, given its direct alignment with energy-related endeavors. Besides, sustainable energy training also intersects with several other SDGs, particularly those pertinent to the offerings at ETSII. These include:

- *SDG 9. Industry, innovation and infrastructure*. Goal 9.4, which emphasizes sustainable infrastructure and innovation in clean technologies, crucial elements for advancing towards a more sustainable energy landscape. Training content focusing on decarbonization strongly aligns with this objective.

- *SDG 12. Responsible production and consumption*. Addressing energy efficiency and responsible resource utilization (goal 12.2) contributes to sustainable energy practices.

- *SDG 13. Climate action*. Goal 13.3, which underscores the role of education in combating climate change. Here, promoting the shift towards sustainable energy sources directly intersects with the training objectives under analysis.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

By considering these SDGs, we aim to evaluate both the existing sustainable energy training within ETSII programs and the potential for further developments. Our insights are drawn from SDG training reports generated through the PIME initiative. The management staff of ETSII is compromised in enhancing SDGs training in the different degrees, so informative campaigns are regularly launched to disseminate the actions taken in this direction.

3. Results

3.1 Current training maps in subjects related to sustainable energy in ETSII

It has been determined that 7 out of 15 degrees offered at ETSII are related to training in the field of sustainable energy, specifically: GIE (Degree in Energy Engineering), GIQ (Degree in Chemical Engineering), GITI (Degree in Industrial Technologies Engineering), MUCII (Master Degree in Industrial Constructions and Installations), MUII (Master Degree in Industrial Engineering), MUIQ (Master Degree in Chemical Engineering) and MUTEDS (Master Degree in Energy Engineering for Sustainable Development). Considering the aforementioned SDGs, it has been identified those subjects taught in the degrees of the ETSII that are related to the topics of decarbonization, circular economy, renewable energy, energy efficiency and any other facets concerning to the contribution to sustainable energy. Table 1 shows the data pertaining to the mandatory subjects, specifying the associated degree, the course, the current number of enrolled students and which is the aforementioned topic it addresses.

The degrees demonstrating the highest number of subjects related to sustainable energy are GIE and MUCII. Approximately 865 students have received training in sustainable energy, with GITI and MUII being the most significant contributors, accounting for the highest percentages of students at 31% and 40%, respectively. To assess the overall impact of each degree, Table 2 has been compiled. In the last column, the *global impact* has been computed by multiplying the number of students within each degree by the quantity of compulsory subjects currently working on SDGs related to sustainable energy. The results from the table consistently underscore GITI and MUII as the degrees exerting the most substantial global impact, with GIE following closely behind.

3.2 Training potential in sustainable energy

In this PIME, an assessment has been conducted to identify the number of compulsory subjects within each degree that have the potential to incorporate, albeit currently not doing so, aspects related to the previously identified SDGs (subjects specified in Table 1 have been omitted). The outcomes are delineated in Table 3, wherein the last column includes the potential global impact of each degree: the mean number of students enrolled in each degree (Table 2) multiplied by the summation of the current and potential number of subjects indicated in Table 3. From the degree data it is clear that MUCII and MUTEDS have already fully integrated all the possible teaching linked with sustainable energy. Besides, GIQ, GITI

BY-NC-SA 2024, Editorial Universitat Politècnica de València

and MUII emerge with the potential of incorporating it and include 4-5 subjects each. These incorporations could result in a substantial increase in impact, particularly for GITI and MUII, as these degrees currently accommodate the highest student enrolment at ETSII.

Table 1. Subjects taught in ETSII that are related to sustainable energy (Source: prepared by the authors)

Degree	Subject	Course	Students	Related content
GIE	Energy and sustainable development	2	105	Renewable energies and decarbonization
GIE	Thermal renewable energies	3	84	Renewable Energies
GIE	Energy audit	4	50	Circular economy
GIE	Wind energy and electricity generation with renewable energies	4	63	Renewable energies and decarbonization
GIQ	Industrial heat and cold	3	53	Decarbonization and air conditioning
GIQ	Environmental technology	3	69	Circular economy
GITI	Environmental technology	3	291	Circular economy
GITI	Enegy technology	4	246	Renewable energies
MUCII	Energy certification of buildings	2	17	Decarbonization, Zero Energy Buildings (ZEB)
MUCII	Lighting installations	1	24	Energy efficiency in lighting
MUCII	Cold and air conditioning installations	1	13	Energy efficiency in air conditioning
MUCII	Fluid installations	1	13	Circular economy. Zero Energy Buildings (ZEB)
MUCII	Electric installations	1	13	Energy efficiency
MUCII	Heat and cold production	1	13	Energy efficiency and decarbonization
MUCII	Urban electrical distribution networks	1	12	Sustainable infraestructures
MUCII	Air conditioning and energy efficiency systems	2	17	Zero Energy Buildings (ZEB), Energy efficiency
MUCII	Industrial ventilation	1	13	Improved indoor air quality
MUII	Heat, cold and air conditioning	1	347	Energy efficiency in air conditioning
MUIQ	Hot and cold installations	1	52	Decarbonization
MUTEDS	Desing and project of energy systems	1	36	Energy efficiency and decarbonization
MUTEDS	Assessment of environmental impact of energy systems	1	40	Life cycle analysis
MUTEDS	Energy audit practices	1	36	Zero Energy Buildings (ZEB), Energy efficiency

Source: Own elaboration

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

To promote the integration of the SDG training potential indicated in Table 3, the School has defined different strategies among which it is worth highlighting: the dissemination of these results among the teaching staff involved through the ETSII website, and the organization of a conference on SDG teaching in which the most outstanding works will be recognized.

Table 2. Impact analysis by degrees (Source: prepared by the authors)

Degree	Mena number of enrolled students	Number of compulsory subjects (currently working on SDGs)	Global impact
GIE	76	4	304
GIQ	69	1	69
GITI	**269**	**2**	**538**
MUCII	15	9	135
MUII	**347**	**1**	**347**
MUIQ	52	1	52
MUTEDS	38	3	114

Source: Own elaboration

Table 3. Additional teaching potential in sustainable energy (Source: prepared by the authors)

Degree	Current subjects				Potential subjects	Possible subjects (current + potential)	Potential global impact
	SDG 7	SDG 9	SDG 12	SDG 13			
GIE	2	-	2	-	3	7	532
GIQ	**2**	**1**	**2**	**-**	**4**	**5**	**345**
GITI	**4**	**3**	**-**	**-**	**5**	**7**	**1883**
MUCII	-	1	-	-	1	10	150
MUII	**2**	**2**	**1**	**-**	**4**	**5**	**1735**
MUIQ	1	1	-	1	2	3	156
MUTEDS	-	-	-	-	0	3	114

Source: Own elaboration

4. Conclusions

The project's findings underscore the significant role of ETSII in promoting SDG training. Seven degrees are directly linked to sustainable energy, emphasizing the institution's commitment to SDGs 7, 9, 12, and 13. The integration of SDGs into the curricula has the potential to impact a large number of students, helping them to develop a deeper understanding of SDGs and preparing them to tackle global challenges. Specifically, 168 teachers are currently collaborating in the project, teaching in more than 130 subjects. The project's methodology, involving the review of Teaching Guides and surveys, allowed for a comprehensive assessment of the current state of SDG training at ETSII. In the future, an adequate training itinerary will bridge the gap between the current state and the desired future, ensuring effective integration of SDGs into the curriculum. By equipping students with the knowledge and skills necessary for a sustainable future, ETSII is contributing to the realization of the 2030 Agenda.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

The authors would like to thank the Higher Technical School of Industrial Engineering (ETSII) support and the funding from Universitat Politècnica de València through Educational Innovation and Improvement Project PIME/21-22/281, as well as all the teachers who have collaborated in obtaining of the results of this work.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Boletín Oficial del Estado nº 233, de 29/09/2021 (BOE-A-2021-15781). Madrid: Ministerio de la Presidencia, Relaciones con las Cortes y Memoria Democrática. Gobierno de España.

CEO Statement of Continued Support for the Sustainable Development Goals. United Nations Global Compact. 2023. https://unglobalcompact.org/library/6142. Accessed 15/01/2024.

Esteso, A., Lull, C., Lapuebla-Ferri, A., Villanueva López, J.F., Sancho, M., Gallardo Bermell, S., Vallés-Lluch, A., Martínez-Gómez, M., Alemany, M.M.E., Ortiz, Á. (2023). Diagnosis of awareness of the sustainable development goals among students and lecturers in higher education engineering school. *INTED2023 17th International Technology, Education and Development Conference Proceedings*, 4990-4999. https://doi.org/10.21125/inted.2023

G20 Action Plan on the 2030 Agenda for Sustainable Development. https://www.b20germany.org/. Accessed 15/01/2024.

Martínez-Gómez, M., Gallardo Bermell, S., Villanueva López, J.F., Sancho, M., Lull, C., Esteso, A., Vallés-Lluch, A., Lapuebla-Ferri, A., Alemany, M.M.E., Ortiz, Á. (2023). Diagnosis of training in sustainable development goals in the higher technical school of industrial engineering (ETSII). *INTED2023 17th International Technology, Education and Development Conference Proceedings*, 4969-4977. https://doi.org/10.21125/inted.2023

UN. 17 Goals to Transform Our World. www.un.org/sustainabledevelopment. Accessed 15/01/2024.

Vallés-Lluch, A.; Lapuebla-Ferri, A.; Alemany, M. M. E.; Villanueva, J. F.; Esteso, A.; Gallardo, S.; Fuster, M. V.; Andrés, J.; Sancho, M.; García-Serra, J. (2022). Mapping the implementation of Sustainable Development Goals in engineering university studies. *INTED2022 16th International Technology, Education and Development Conference Proceedings*, 5192-5201. https://10.21125/inted.2022.

Villanueva, J. F.; Fuster, M. V.; Esteso, A.; Andrés, J.; Vallés-Lluch, A.; Lapuebla-Ferri, A.; Gallardo, S.; Alemany, M. M. E.; Sancho, M.; García-Serra, J. (2022). The point of view of teachers before the Sustainable Development Goals: a review prior to its implementation in a school of engineering. *INTED2022 16th International Technology, Education and Development Conference Proceedings*, 5219-5226. https://10.21125/inted.2022.

Voluntary National Reviews. https://www.ohchr.org/es/sdgs/voluntary-national-reviews. Accessed 15/01/2024.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Escaperoom In Energy Education

Joost Jongen

[a]HU, Netherlands

Abstract

This paper focuses on utilizing the Celciushouse as an escape room in energy education. In a broader context, it also addresses the incorporation of serious gaming in education. The project is part of COVE SEED. SEED - Sustainable Energy Education, aims to develop innovative vocational education and training, working with experts from five different European regions to phase out fossil fuels and contributing to Europe becoming a fossil free energy continent. SEED is a CoVE (Centres of Vocational Excellence) programme. CoVE's are part of the Erasmus+ program aiming to establish transnational platforms on, among others, regional development, innovation and inclusion. SEED combines education on various international levels including level 2,3,4, and 6.

At this moment, the project ESCAPEROOM IN ENERGY EDUCATION is still in its initial phase. With this paper and the accompanying workshop, we aim to gather insights from other international regions involved in the SEED project collaboration.

The acceleration of technological developments means that what is learned today may be outdated tomorrow. Therefore, it is essential for educational institutions to focus on developing general skills such as critical thinking, problem-solving, and the ability to quickly absorb new information. The market demands professionals with modern knowledge and skills. Techniques taught to students today may become outdated tomorrow. Therefore, the ability to learn how to learn is becoming increasingly crucial. Analytical and research skills are therefore gaining importance. It is also essential for students to utilize various learning methods. Not just learning from books but particularly learning from practical experience.

Practice-oriented learning, where students gain direct experience in real situations, not only reinforces theoretical knowledge but also develops practical skills that are valuable in the job market.

To tackle these problems, serious gaming or the establishment of escape rooms can be a solution.

Keywords: Escaperoom, Eduscaperoom, Educational Escape Rooms (EERs).

How to cite: Jongen, J. (2024) Escaperoom In Energy Education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 25-33. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acronym: COVE SEED

C: Challenging

O: Outcome-oriented

V: Virtual

E: Exciting

S: Story-driven

E: Educational

E: Engaging

D: Dynamic

Fig. 1 – Example Escape room



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

Introduction

The Celsius House, constructed by students from University of Applied Sciences Utrecht, triumphed in the 'Solar Decathlon Challenge.' This competition was played in the year 2021. They did this in collaboration with ROC Midden Nederland and several business partners. The Celcius-house has won several awards in various categories. At the moment, the Celciushuis is located near Amersfoort Schothorst.

The Celsius House aims to function as a workspace for testing new sustainable technologies and undertaking challenging study projects related to smart, sustainable cities. The proposal is to transform the Celsius House into an escape room, aligning with its current phase and the need for an educational purpose. This paper explores the potential of using an escape room format to teach modern technologies integral to the upcoming energy transition, aligning with the trend of incorporating serious gaming in education.

COVE SEED

The COVE SEED skills analysis revealed crucial skills, including:

1. Less theory for theory's sake but to support practice.
2. Direct application of learned concepts.
3. A shift towards more hands-on experience compared to theoretical examinations.

Furthermore the European transversal skills and competences (ESCO;s) (Europese Unie, z.d.) are investigated. There are various transversal skills that can be acquired through the application of Serious Gaming in general or Escape Rooms in particular. Refer to Table 1.

Fig. 2 – Celcius house



Source: HU (2021)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1 – ESCO

T	transversal skills and competences	Applicable on Escape-rooms;
T1	core skills and competences	
T1.1	mastering languages	
T1.2	working with numbers and measures	Yes
T1.3	working with digital devices and applications	Yes
T2	thinking skills and competences	
T2.1	processing information, ideas and concepts	Yes
T2.2	planning and organising	
T2.3	dealing with problems	Yes
T2.4	thinking creatively and innovatively	Yes
T3	self management skills and competences	
T3.1	working efficiently	
T3.2	taking a proactive approach	Yes
T3.3	maintaining a positive attitude	
T3.4	demonstrating willingness to learn	Yes
T4	social and communication skills and competences	
T4.1	communicating	Yes
T4.2	supporting others	Yes
T4.3	collaborating in teams and networks	Yes
T4.4	leading others	
T4.5	following ethical code of conduct	
T5	physical and manual skills and competences	
T5.1	manipulating and controlling objects and equipment	
T5.2	responding to physical circumstances	Yes
T6	life skills and competences	
T6.1	applying health related skills and competences	
T6.2	applying environmental skills and competences	
T6.3	applying civic skills and competences	
T6.4	applying cultural skills and competences	
T6.5	applying entrepreneurial and financial skills and competences	
T6.6	applying general knowledge	Yes

Source: ESCO (z.d.)

Objective

To address the aforementioned challenges, the paper aims to investigate the role escaperooms could play in energy education. The primary question is:

How can escaperooms be effectively utilized in energy education, and what conditions contribute to their success?

2024, Editorial Universitat Politècnica de València BY-NC-SA

Subsidiary questions include:

1. Which design principles are valid for escape rooms?
2. What are the prerequisites for implementing escape rooms in education?
3. How does the application of escape rooms differ between Vocational Education (level 4) and Higher Education (level 6)?
4. To what extent does the use of escape rooms attract potential students, contributing to the appeal of the technology/energy domain?

The answers in this paper are certainly not sufficient. Much more research is needed. The workshop will be utilized to initiate the process of gathering more and better answers.

Design Principles of Escape-Rooms

Effective escape room design involves integrating key principles to ensure a challenging, enjoyable, and immersive experience. Design principles include:

- Clear Theme and Storyline
- Logical Puzzles and Challenges
- Progressive Difficulty
- Team Collaboration
- Immersive Environment
- Clear Clues
- Multiple Paths to Success
- Engaging Integration of Technology
- Feedback Mechanisms
- Thematic Consistency
- Flexible Intervention by the Game Master

Education level

The disadvantage of an escape room is its one-time usability, offering only one solution to each problem. This appears mismatched for level 6 education. Level 2 and 3 education aligns more with this concept. However, discussions with HU colleagues of the ICT department reveal the feasibility of incorporating multiple levels simultaneously. One group could solve puzzles, while the other observes (source, 2022).

Appeal

By increasing motivation among students in a program, the field of Energy ultimately becomes more appealing. By immersing learners in a playful, interactive, and engaging experience, Educational Escape Rooms (EERs) have been found to enhance learners'

BY-NC-SA 2024, Editorial Universitat Politècnica de València

motivation, help them to develop 21st century skills, and improve knowledge acquisition. (Panagiotis Fotaris 1, 2022). In the Netherlands, there are various initiatives to make technical education, especially in the energy sector, attractive. Escape rooms can certainly contribute to this. (WijTechniek, zd)

Examples

There are several examples of puzzles to consider. The first example is the scenario involving phase dropout. This situation could be played out in reality. An alternative is to use a simulation program. Students can then simply sit at the table and solve the puzzle. A combination is also possible.

A second example is the control system of the heat pump. Controlling and adjusting a heat pump must be done quite precisely. If the heat pump is poorly regulated, it does not operate in its optimal state. The efficiency becomes low, and the lifespan decreases.

In the Celsius House, we can also choose between a simulation or a real situation for this case. A disadvantage of real situations is that there is not always a real heat demand. In winter, the students would literally get cold if the heat pump does not function optimally.

In the workshop, we could start with a computer game to control something. You can let participants try to land a probe on the moon. Too much rocket thrust would cause the probe to move far from the moon or crash, too little thrust, and it takes forever. This is a game that, in my opinion, is easy to program.

If the game works, we can create something similar for the control of the heat pump.

Another example of a puzzle could be about the building envelope of the Celsius House. The question is, what is the optimal thermal resistance of the wall to minimize heating and cooling costs in winter and summer, respectively? In winter, the resistance value should be as high as possible to reduce heating costs. However, in summer, a thick building envelope is not always advantageous because you want to release heat through the wall. Overheating of homes is currently an issue in housing construction. A simple Excel spreadsheet can be a valuable tool here.

Field research

On March 28, 2024, field research was conducted on the concept of using escape rooms in education. A brief workshop (1.5 hours) took place with colleagues. The central research questions were as follows:

- What types of tasks are possible?
- Which contexts should be addressed? (technical, economic, legal, social?)

2024, Editorial Universitat Politècnica de València BY-NC-SA

- How can the escape room be used for longer periods than once per student?
- What are the key points to consider for its use in regular education?

The following answers were formulated by colleagues:

Colleague 1: Ensure that all tasks revolve around the energy transition. Make it a multi-day escape room. The first day focuses on the technical aspect, the next day on the social aspect, the following day on the legal and economic aspects, and finally on the environmental aspect. Don't forget about nature! Example challenge: insulation thickness, connecting heat pipes to heat supply. Have students create the tasks. After playing, have them complete an additional task.

Colleague 2: Possible themes; 1) energy demand and supply imbalance, or network congestion. 2) How to make a home energy neutral and what is needed for that? 3) How to make an old home (e.g., built in 1960) gas-free? 4) Energy transition and dealing with energy poverty. 5) District heating networks a) insulation required for pipes and buildings b) space in the underground, i.e., urban planning c) types of heat sources and pipe materials d) how to convince the majority of residents to take action?

Colleague 3: The storyline revolves around a house that is part of an energy network. How do you optimize your eco-footprint? How do you optimize costs? How do you optimize collaboration (socially) within a network? For example, communicating with another house. "Troefspel" , Troefgame * serves as an example for practical learning "how it works" in small games but also within the entire house. Optimizing appliances, closed-loop systems, think of: Apollo 13.

*"Troefspel" is a game developed by the University of Applied Sciences Utrecht as part of the trump project. With this game, students can try to solve a network congestion problem by playing various scenarios in a fun way. The Trump board shows energy flows using burning LED lights. The game has won many awards. Colleague 4: I believe that the storyline for the Celsius House should revolve around building the house for the Solar Decathlon Challenge. You can then calculate how to assemble your house to win the competition. Perhaps you can choose 3D-printed components after each task.

Colleague 4: I believe that the storyline for the Celsius House should revolve around building the house for the Solar Decathlon Challenge. You can then calculate how to assemble your house to win the competition. Perhaps you can choose 3D-printed components after each task.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Methodology

To realize an escape room the following approach is suggested

- Define Objectives: Identify energy concepts.
- Design Challenges: Create puzzles aligned with objectives.
- Incorporate Content: Integrate educational information.
- Create Elements: Develop game components.
- Trial Run: Test and adjust based on feedback.
- Facilitator Training: Train guides.
- Launch and Evaluate: Implement, gather data, and refine.

Actual steps and near Future

The first steps have already been taken. The project has been initiated with students as part of Quest. A group of 6 students has been working on it since February. The project is still in the exploratory phase. The project plan has just been drafted. The current phase of the project is focused on researching and identifying the requirements and wishes of the client. Next, the phase of planning the project implementation will follow. By summer, there should be a definitive plan in place. Furthermore, before summer, a concrete puzzle will already be delivered in physical form. The group is very enthusiastic and intends to develop a solid plan.

After the summer we continue with a more in-depth exploration of challenges and potential drawbacks. Also a little more linking material in the form of more theoretical background has te be established.

In near future, we must explain more about how the Escape Room concept relates to the various Serious Gaming possibilities that may be applied. Similarly, further exploration is necessary how the escape room fits in the programs of study students of various levels are undertaking and the size of the cohort. Building on the latter, we also must make clear how the approach may scale to a large cohort.

Conclusion

In this paper the primary question is which stood central is:

How can escaperooms be effectively utilized in energy education, and what conditions contribute to their success?

This paper is the start of an exploration of the potential of using an escape room in technical education.

Educational escaperooms can be a big plus to our education. The most value part is where students of different levels can work on puzzles, objectives simultaneously. There are plenty

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

of ideas but none of them is done and have been tested yet. Using proposed design principles and make first steps by try and erroring would be a realistic approach. In the next couple of months the approach is focusing on the main point, further discussing the objectives, methods and findings. In any case the whole concept warrants further investigation. The idea is to start in any case with a small group and develop knowledge what is working and what is not.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Europese Unie. (z.d.). Opgeroepen op Januari 31-1-2024, 2024, van https://esco.ec.europa.eu/en/classification/skill_main#overlayspin

Panagiotis Fotaris 1, *. a. (2022). Room2Educ8: A Framework for Creating Educational Escape Rooms Based on Design Thinking Principles. MDPI, Basel, Switzerland: Basel, Switzerland.

WijTechniek. (zd). Samenwerken aan techniekonderwijs. Opgehaald van Wij techniek: https://www.wij-techniek.nl/samen-werken-aan-techniekonderwijs/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Aeromimetics

Juan Antonio Sánchez Serrano

IES Antonio Navarro Santafé/Electricity, Electrónics and Renewable Energy, VET GVA, Spain

Abstract

Wind Power plays a key role in the the energy transition as it is an important renewable energy source on the global scale. Developing this technology is vital for the present and future of our society. The main goal of Aeromimetics is to develop new shapes of wind turbine blades inspired in living things using a technique called Biomimicry. To conduct this innovative research, a scale model of a wind turbine and a wind tunnel were designed and constructed. The study is supported by the data achieved from the models of two different types of blades tested in an automated machine that incorporates cutting-edge Industry 4.0 technologies. The data collected was used to conduct a statistic analysis ensuring accuracy and reliability of both the wind turbine and the wind tunnel. Findings indicate that regardless the new model of blades are less efficient than their original counterparts, the wind turbine and the wind tunnel are sufficiently reliable to keep designing and testing new models of future biomimetic blades.

Keywords: Biomimicry, Wind Power, Industry 4.0, Automation.

How to cite: Sánchez Serrano, J.A. (2024) Aeromimetics. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 34-41. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Aeromimetics is a wind turbine testing machine dedicated to the development of blades inspired by shapes present in nature using a technique called Biomimicry. This project, designed and built in a VET school, encompasses three main lines of action:

- Creation of a scale wind turbine using additive manufacturing.
- Investigation of terrestrial and marine ecosystems to identify inspiring shapes or details for incorporation into the wind turbine blades.
- Development of an automated and digitalized wind turbine test machine.

The merge of these three strategic lines of work results in a machine that allows the school to explore and develop new wind turbine blade models.

The main objectives of the project are:

- Promotion of Sustainable Development Goals
- Integration of industry 4.0 technologies Education
- Environmental Awareness through Material Reuse.

Fig. 1 – Aeromimetics



Source: Personal photo

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. The project

2.1 Wind Turbine

The school has designed and manufactured a functional wind turbine capable of transforming the kinetic energy of the wind into mechanical energy. The wind turbine rotor and an electric motor act as an alternating current generator. The electric motor produces alternating current, which is rectified and smoothed in a rectifier and prepares the signal to be read and processed by a PLC (Programmable Logic Controler).

The wind turbine was crafted using PLA (Polylactic acid). The main characteristics of PLA, a materialderived from corn starch, lies in its sustainable origin, making it an environmentally friendly.

Fig. 2 – Wind turbine parts



Source: Personal photo

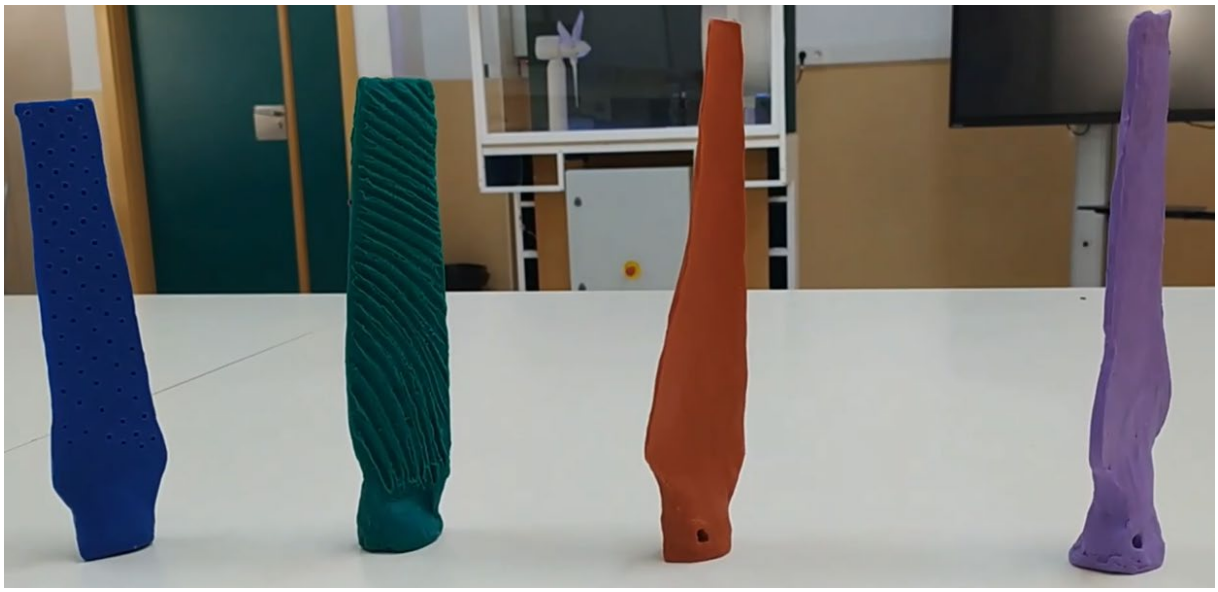
2.2 Biomimetic blades

A study of marine and terrestrial ecosystems was conducted and different ideas were proposed aiming at generating new wind turbine blades with the aim of provide some advantage over conventional blades. Eight new designs, all of them based on the observation and interpretation of biological shapes, were considered but only one of them was manufactured, studied and compared with the original blade on the testing bench. The chosen one was considered the most cost-effective to manufacture and demonstrated the potential for yielding favorable results after the study.

2024, Editorial Universitat Politècnica de València BY-NC-SA

The image below illustrates the variety of new blades that students developed.

Fig. 3 – Biomimetic Blades



Source: Personal photo

Shark skin riblets, pollen external structures, bird wings or some seeds were the inspiration of the students to create those models. The model that was selected to continue with the development process was the one based on pollen external structures similar to golf balls.

The new design was supported by the idea of reducing air friction by using blades with multiple small holes like the ones present in pollen. Wind turbine blades can achieve extremely high speeds, so reducing friction should improve turbine efficiency.

2.3 Testing bench

The wind turbine testing bench was manufactured almost entirely with reused materials.

State of the art technologies from the Industry 4.0 were integrated in the project. Additive manufacturing, 3D scanning, Digital Twin, IoT and Cloud Control, Virtual reality and Cybersecurity were used in order to provide traceability and reliability in the study results.

In automatic mode, the system performs a sequence of six controlled wind speeds and takes five power measurements separated by a two-second interval between each. The speed sequence is as follows:

- 40 seconds – Wind speed: 15 Km/h.
- 30 seconds – Wind speed: 16 Km/h.
- 30 seconds – Wind speed: 17 Km/h.
- 20 seconds – Wind speed: 19 Km/h.

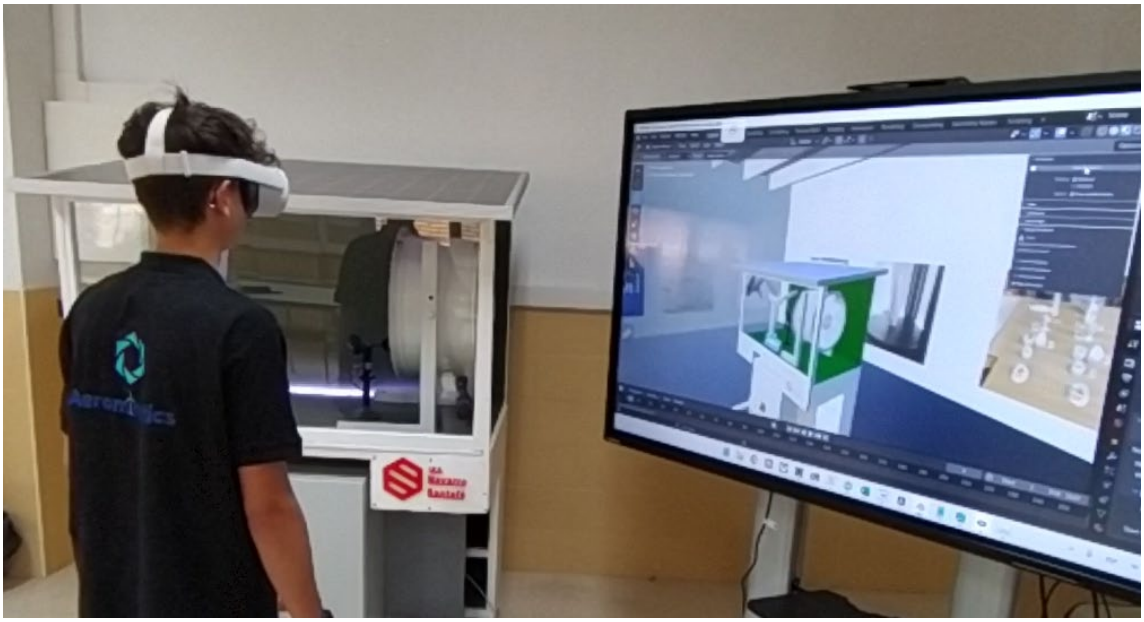
BY-NC-SA 2024, Editorial Universitat Politècnica de València

- 20 seconds – Wind speed: 21 Km/h.
- 20 seconds – Wind speed: 23 Km/h.

One of the most interesting aspects of the project is the way data is handled and processed. First of all, creating a machine that performs a standardized process in the absence of human intervention increases reliability and reduces the probability of failure. The same process is repeated any time the cycle starts (wind speeds, time steps, and data reading moment). The cycle is carried out in the same way regardless of the number of repetitions, time of day or any other factor that could cause any operator to make an error.

An additional aspect of Aeromimetics is the development of a 3D environment including photos, videos, 3D models and more elements. This immersive experience allows anyone to learn about the project without any need of being physically present with the machine. Aeromimetics is placed within a virtual gallery developed using a videogame tool. Virtual reality is a tool that allowed the students to overcome barriers and liberating creativity from imposed limits.

Fig. 4 – Virtual Gallery



Source: Personal photo

3. Energy efficiency study and results

The power studies were conducted in order to keep the same external conditions, such as time of day, place and in the absence of nearby objects both in front and behind the tunnel.

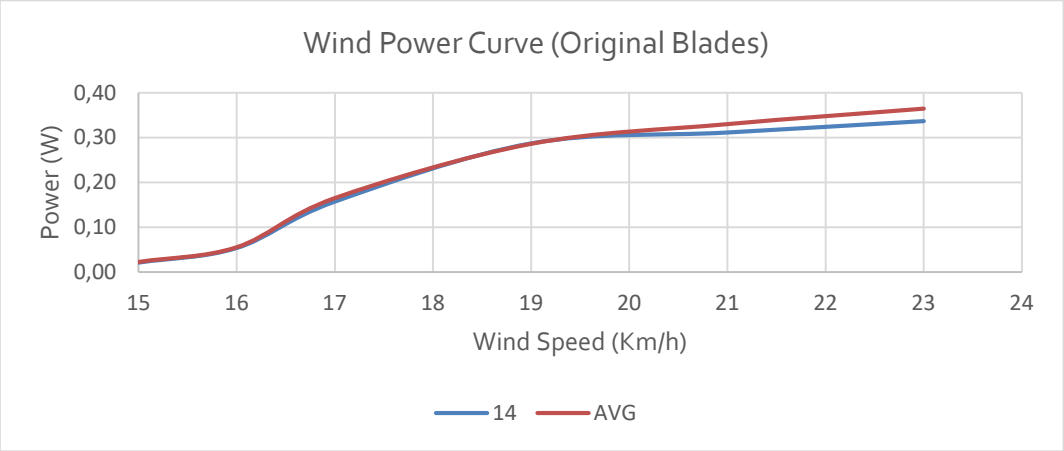
Every time the automatic program is launched, the system records five power measurements for each of the six speed steps. This test was carried out eighteen times for

2024, Editorial Universitat Politècnica de València BY-NC-SA

both the original blade and the biomimetic blade. A statistics study was undertaken to comprehend and interpret behavior of each blade.

The Reliability of the models can be shown as the results form a single study (14) are quite close to the average of the eighteen studies (AVG). The models consistently demonstrated high performance as the following image shows.

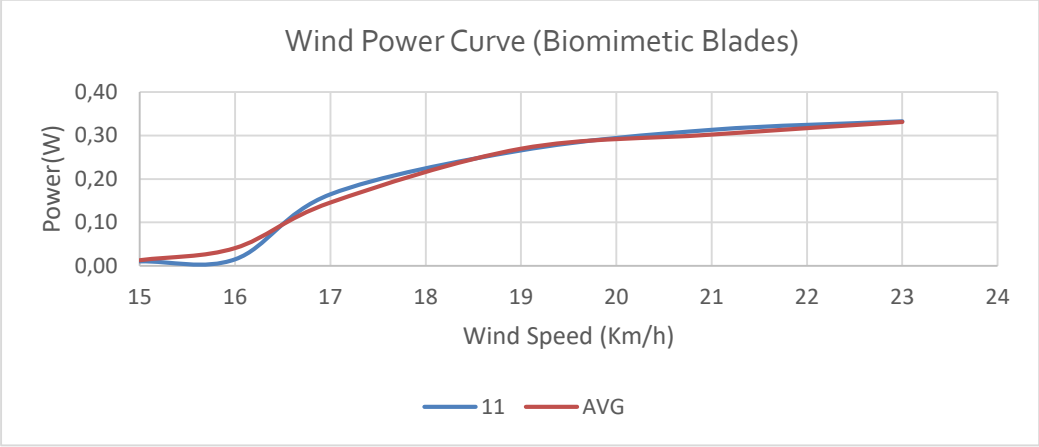
Fig. 5 – Single study versus average. Original Blades



Source: Personal photo

A similar curve can be obtained with the Biomimetic blade's data (11 vs AVG).

Fig. 6 – Single study versus average. Biomimetic Blades

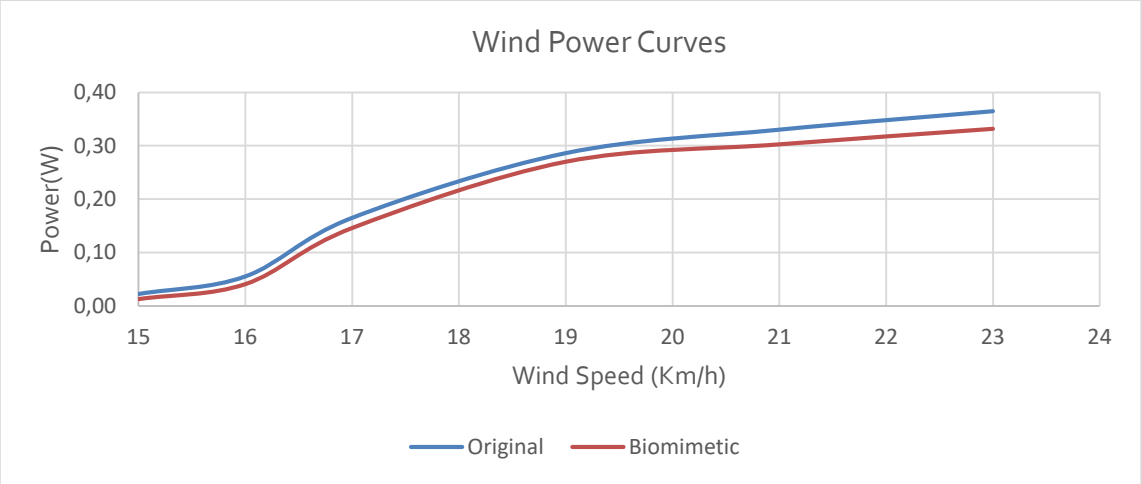


Source: Personal photo

The aim of the study was to compare the performance and efficiency of the original blades with the biomimetic blades. The efficiency can be compared by plotting the average of the eighteen results for each type of blade. The following graph shows these results.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 7 – Original versus Biomimetic average curve



Source: Personal photo

The first thing that can be highlighted from this comparison is the similarity in the shape of both curves. After carrying out eighteen tests under controlled conditions, it was surprising that the average results were so similar, showing the reliability and accuracy of the model.

4. Conclusion

The initial hypothesis was that Biomimetic Blades will reduce air friction improving the efficiency of the turbine. As depicted in the graphs, alterations of the blade surface decreased the power generated by the wind turbine between 5 and 10%. One of possible explanation for these results could be that the holes were placed in both sides of the blade. A potential refinement could involve incorporating holes exclusively in the lower part of the blade to reduce air friction while maintaining higher lift and drag. In the near future, a new and improved model will be explored and studied.

Acknowledgements

No funding has been received for the development of this research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València BY-NC-SA

References

Álvarez, R. (2017). Esta turbina eólica está inspirada en los colibríes y asegura ser más silenciosa y segura para las aves. Xataka. https://www.xataka.com/energia/esta-turbina-eolica-esta-inspirada-en-los-colibries-y-asegura-ser-mas-silenciosa-y-segura-para-las-aves

Cabodevilla, X. (2019). Morfología del ala en jóvenes y adultos de aves de hábitos terrestres. DIGITAL.CSIC. https://digital.csic.es/handle/10261/175185

Coello, Z. (2021). Aves que no vuelan - Características y ejemplos. expertoanimal.com. https://www.expertoanimal.com/aves-que-no-vuelan-caracteristicas-y-ejemplos-24035.html

Comunidad de Madrid. Aerobiología. Polen y esporas. https://www.comunidad.madrid/servicios/salud/aerobiologia-polen-esporas

CORDIS Article. Escamas de tiburón en álabes para aumentar la eficiencia de las turbinas eólicas https://cordis.europa.eu/article/id/406985-riblets-on-wind-turbines-help-them-go-with-the-flow-more-efficiently/es

Cubos Ramírez José M., Pérez Mota Eduardo, Solorio Ordaz Francisco J., Vicente y Rodríguez William. Aerodinámica de las pelotas deportivas. http://somim.org.mx/memorias/memorias2010/A5/A5_274.pdf

OneAir. ¿En qué se parecen los aviones a los pájaros? (2022). https://www.oneair.es/en-que-se-parecen-aviones-pajaros/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

A full integrated teaching method. The experience of a postgraduate master's degree in building energy efficiency design

Matteo Iommi[a], Angelo Figliola[b], Nico Monteferrante[a] and Giuseppe Losco[a]

[a]School of Architecture of Ascoli Piceno, University of Camerino, Italy
[b] Department of Planning, Design, Technology of Architecture, Sapienza University of Rome, Italy

Abstract

Teaching sustainable and high energy efficiency building design, facing against climate change, requires nowadays a well structured multidisciplinary expertise which needs to be transferred to graduate students and young architects, who in turn will have to be able to manage a large number of aspects at different levels and contexts. The paper describes a multidisciplinary teaching approach, supported by a coordinated and extensive use of energy design tools and Building Information Modeling (BIM) tools. The postgraduate master's degree in building energy efficiency is based on a consistent methodology, carried on and implemented during years, providing a fully integrated teaching method. As a fundamental part of the master is the coupling of building design workshops and energy design support tools, applied as widely as possible into the entire design process, from urban planning to building components. Architecture, climate, building technology, building physics and environmental-energy building certifications are take into consideration at once. The postgraduate master aims to encourage students into an integrated design approach, brings together all these aspects. The overall framework, contents, and design support tools are illustrated, linked to some relevant outputs and results produced by students, with which show applicability of the fully integrated method in practice. A critical review on the effectiveness of this integrated teaching program, which tries to address students to a comprehensive preparedness, is described, highlighting remarks, limits, advantages and possible advances.

Keywords: postgraduate master's degrees; integrated design process; energy design tools; environmental design.

How to cite: Iommi, M.; Figliola, A.; Monteferrante, N. and Losco, G. (2024) A full integrated teaching method. The experience of a postgraduate master's degree in building energy efficiency. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 42-51. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Climate change mitigation, sustainability, high energy efficiency, environmental quality have become for several years main topics into the building design in every context, from urban scale to detail scale (EEA, 2018) (IPCC, 2023). These topics in the era of the Anthropocene (Crutzen, 2005) take on a broad and transdisciplinary connotation, encompassing scientific, technological, as well as humanistic and relational meanings. On one hand, there is the need to combat climate change through the reduction of energy consumption and the mitigation of CO_2 emissions, promoting regenerative processes (Naboni and Havinga, 2019). On the other hand, there is a necessary revaluation of economic development models and social relationships. Young architects or new professionals in general need to found and to start their professional careers, achieving expertises and skills on these topics.

The interdisciplinary fields of study and the complexity of data about all the aspects involved make the learning and the management of the environmental design an hard challenge. Most of all studies and researches in building design indicate that the most efficient, best performing and environmentally sustainable building projects are obtained adopting an integrated design process (Zhigang et al., 2012), in which the various disciplines and aspects involved, if understood and managed together, can lead to improve the overall performance (Ramirez et al., 2023). The challenge of low energy – low climate impact buildings is primarily one of integrated design, defined as the synthesis of climate, architecture, functions, technology, materials, energy loads and systems resulting in a more efficient and comfortable environment (Dunn et al., 2013). This view of integrated design is mainly driven by technical skills, training and capacity to interact with different expertise and knowledge capability. These skills are difficult and time expensive to learn in the field, therefore, it is becoming increasingly important to include the education of how to work with an integrated approach in academic programs and early professionals courses (Kincheloe, 2008). A critical role in this challenge is played by energy building design tools, as well as BIM tools. Energy performance simulation tools, here considered in the widest meaning play a fundamental role in almost all contemporary high performance projects. Constant advances in simulations and digital capabilities extend and reinforce the possibility for new designers to collaborate, to predict, to foresee and to modify scenarios and solutions and ultimately to develop an increasingly integrated design. In this paper are discussed: framework, contents and teaching methods of a postgraduate master's degree in Architecture, specifically dedicated to the environmental energy design, with which trying to address the challenges of a fully integrated design approach (Iommi, 2014). Combining and overlapping design workshops and lessons with the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

learning of several energy building design tools, the course tries to enhance the preparedness of young architects and professionals facing current and future challenges of the environmental design.

2. Data driven environmental design as a teaching approach

The postgraduate master would like to prepare new architects and professionals that embrace the potentiality of computation and environmental analysis in the ever-evolving field of architecture. Through the utilization of data analytics, they can gain insights into various aspects of a building's performance, facilitating informed decision-making and optimization.

The most recent approaches introduce much more complex and multiscalar evaluation parameters (Pedersen et al., 2020), such as biophilia, well-being, and even beauty (e.g., the LBC protocol). Hence, the need arises to promote a systemic and holistic approach to managing change. In this regard, one of the main objectives of Data-Driven Environmental Design (DED) is to re-establish the relationship between form, structure, and the environmental ecosystem within a methodological framework that employs digital technologies. The design of a building based on regenerative principles and conceived as a tool for mitigating the effects of climate change lays solid foundations in the development of the concept and the critical reading of the present and future environmental and socio-cultural context. Therefore, it is crucial to adopt a DED approach and digital performance analysis tools integrated within three-dimensional modelling software to have full control of the process and effectively use the analyses as guidance in concept development. The ability to critically read a specific environmental and entropic context is fundamental to the methodological framework and requires a basic theoretical knowledge of key thermodynamic phenomena and performance requirements.

This approach ensures that design decisions are grounded in real-world performance data rather than theoretical assumptions, leading to more effective and impactful sustainable solutions. Moreover, the use of data enables architects to engage in evidence-based discussions with clients, stakeholders, and policymakers, fostering a collaborative approach to sustainable architecture. Specifically, the teaching methodology aims to introduce students to parametric modeling combined with environmental and energy analysis. Both are necessary to establish a direct connection between the variable parameters that describe the overall morphology and the results obtained from the analysis. The primary objective of DED is to control simple parameters related to form aggregation (voxels oriented design), orientation, glazing-to-wall ratio in the framework of sensitive analysis and specifically for the climate zone of the pilot site. Thus, the teaching activities aims to provide to students the ability to develop data-oriented project controlling parametrically

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

design variables according to site-oriented performative benchmarks. The methodology has been applied with a multi-scalar approach following the didactic framework optimized over the years. In this sense, DED represents the path for the proposed teaching method, to guide students to manage and control multidisciplinary data and transform them in design actions through the all design process.

3. The postgraduate second level master's degree

The master's degree is an Italian postgraduate second level master course, named Ecosostenibilità ed Efficienza Energetica per l'Architettura, organized and managed by School of Architecture of Ascoli Piceno, University of Camerino, established from 2009, dedicated to both architects and building engineers coming from all over Italy. Students who obtain the master's degree develop knowledge and skills about architecture design closely related to sustainability, efficient use of energy, bioclimatic design etc. addressing complex problems concerning: climate, environment, energy systems and buildings. The postgraduate master's degree lasts nine months, divided into two phases: the lesson period and the stage period, for a total duration of 1500 hours.

The course offers a general program, divided into modules and consistent sub-modules, engaging a comprehensive range of topics and disciplines, as previously cited. With the aim to address as many design issues as possible and take into account multiple evaluations and assessments, the postgraduate master course is structured on three areas: macro scale, medium scale and small scale. In every area, all the modules or sub-modules are always present, providing fitted theoretical and operative contents. The macro scale is focused on energy system and policies. In this area, the main topics are: energy markets, energy and sustainable policies. The medium scale is focused on buildings and urban environment. Into the medium scale area the main topics are: design and analysis of systems at urban scale, environmental quality, efficient use of natural resources, climate analysis, site analysis, computational analysis of fluid dynamics and building architecture. The micro scale is focused on building thermal performances, indoor environmental comfort, building envelope, passive and renewable systems, HVAC systems and energy-environmental certifications. At the end of the master, students obtain also qualifications as: BIM Specialist (UNI 11337-7:2017), GBC LEED Italia and Energy Manager Expert (UNI EN 11339). Thanks to the wide range of expertises and to the support of professional stages, included into the master program, students are usually enrolled in offices, finding employment immediately.

3.1 A comprehensive toolkit

The three proposed areas are organized with theoretical and operative sessions, strongly based on DAD and featured by the use of energy design support tools in order to put the theoretical contents into the design practice by favouring a learning by doing approach

BY-NC-SA 2024, Editorial Universitat Politècnica de València

(Figliola, 2018). This approach represents the founding element of the teaching methodology, from the development of the different modules and sub-modules to the final student projects. In relation to the multitude of topics addressed, a toolkit has been organized which finds its synthesis in the use of BIM software, advanced simulation tools and professional software, under national regulatory (Table 1). For instance, students will be supported by tools, such as Meteonorm, Weather Tool, Climate Studio, through which they can generate climate files, analyze data and provide a critical analysis of the environmental context in which they will operate. On the urban scale, other tools are introduced, as ENVI-met, for the study of the microclimate and outdoor comfort. On the building scale, the Master offers the use of BIM and parametric software: Revit--Insight and Rhino-Grasshopper-Ladybug Suite, through which evaluate the development of the project in the early design phases, and provide other simulations on daylighting, solar access analysis and indoor thermal comfort. Furthermore, additional tools and software are used for acoustic, life cycle analysis, thermal bridges, hygrothermal performances of building components, renewable and energy systems.

Table 1 – The Toolkit and related analysis

Tools	A	B	C	D	E	F	G	H	I	J	K
Meteonorm	■■■										
Weather Tool	■■■			■■■							
Climate Studio	■■■										
PMV Tool				■■■							
ENVI-met	■■■			■■■				■■■			
EP / OS		■■■	■■■	■■■	■■■	■■■					
Ladybug Suite	■■■	■■■	■■■	■■■	■■■			■■■			
Revit / Insight		■■■	■■■								
Heat			■■■								
ANIT Suite			■■■						■■■		■■■
PV SOL						■■■	■■■				
RELUX					■■■						■■■
Docet CNR		■■■									■■■
Edilclima						■■■	■■■				
Termo Log		■■■	■■■			■■■	■■■				■■■
ITACA Tool										■■■	■■■
GBC LEED Italia Tool										■■■	■■■

Source: List of the tools and softwares used and taught into the master course. For each tool are indicate type of analysis used for. A: Climate, B: Energy Building, C: Materials, D: Thermal Comfort, E: Daylighting, F: Energy Systems, G: Renewable, H: CFD, I: Acoustic, J: LCA, K: Codes and Standards

Tools are learned by students, applying theme in their ongoing projects to evaluate or to assess their design questions and proposals. Tools are introduced to students early and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

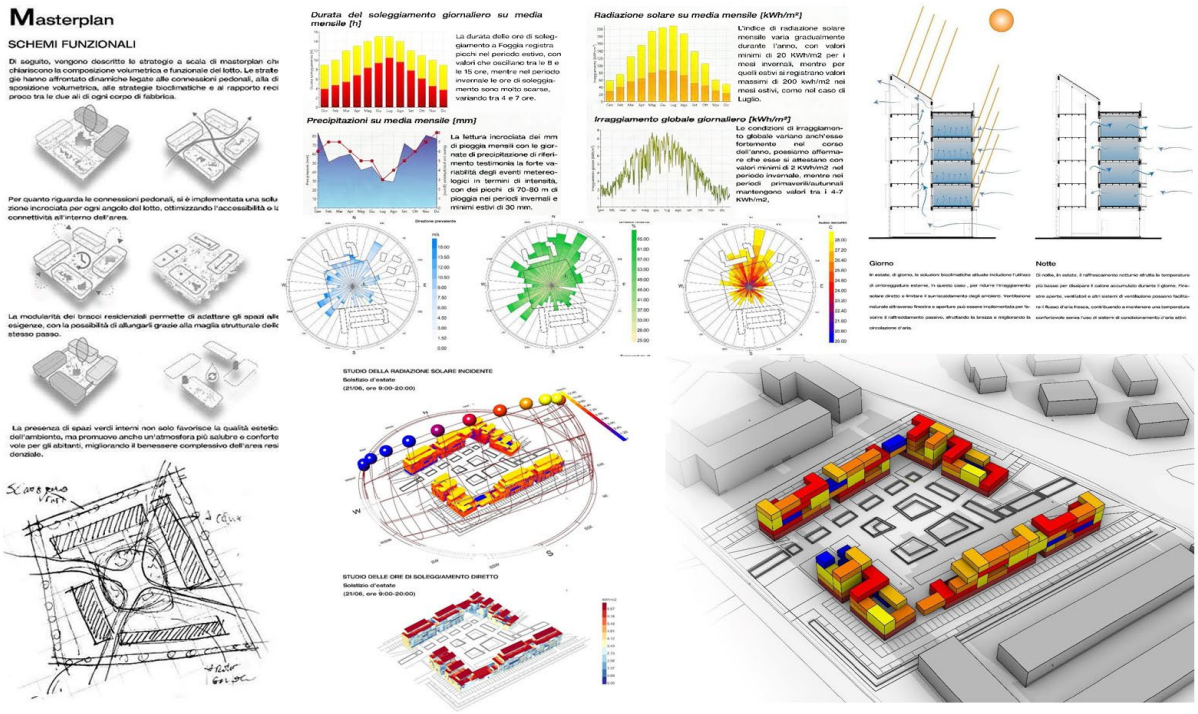
carry on during the entire design process, exploring the variety of functions or types of simulations, achieving a whole view of all possible analysis and design supports.

4. Student work

Based on the teaching approach previously described, the integrated design process is adopted on a common design theme which is applied to selected case studies. The common theme is the development of a small urban district, mainly residential, which has to be designed from scratch, starting from a planning design, through the design of buildings, until the design and the evaluation of the main building components and mechanical equipments with relative energy-environmental certifications. Several case study areas are proposed, sited throughout the entire Italian territory, selected in relation to different climate conditions and urban context, to offer students to engage with different possible sites. Each student chooses at will a case study area, which becomes the personal project. The development of every project by students is constantly supported by the energy design tools. During the lesson period, organized both in person and online, a close time relation with every design phase and the teaching and application of the energy design tools is crucial, also joined to the lessons. Thanks to the toolkit with several and different design tools, students can manage the multidisciplinary condition occurred into their projects (Figg.1-2). A fundamental part of this integrated design process are the workshops, always held in person. Design activities are distributed along the entire course, immediately in the early weeks until the end. The workshops represent intensive design days with the participation of several professors in which students develop their projects and learning by doing, using and applying the design tools directly into their projects.

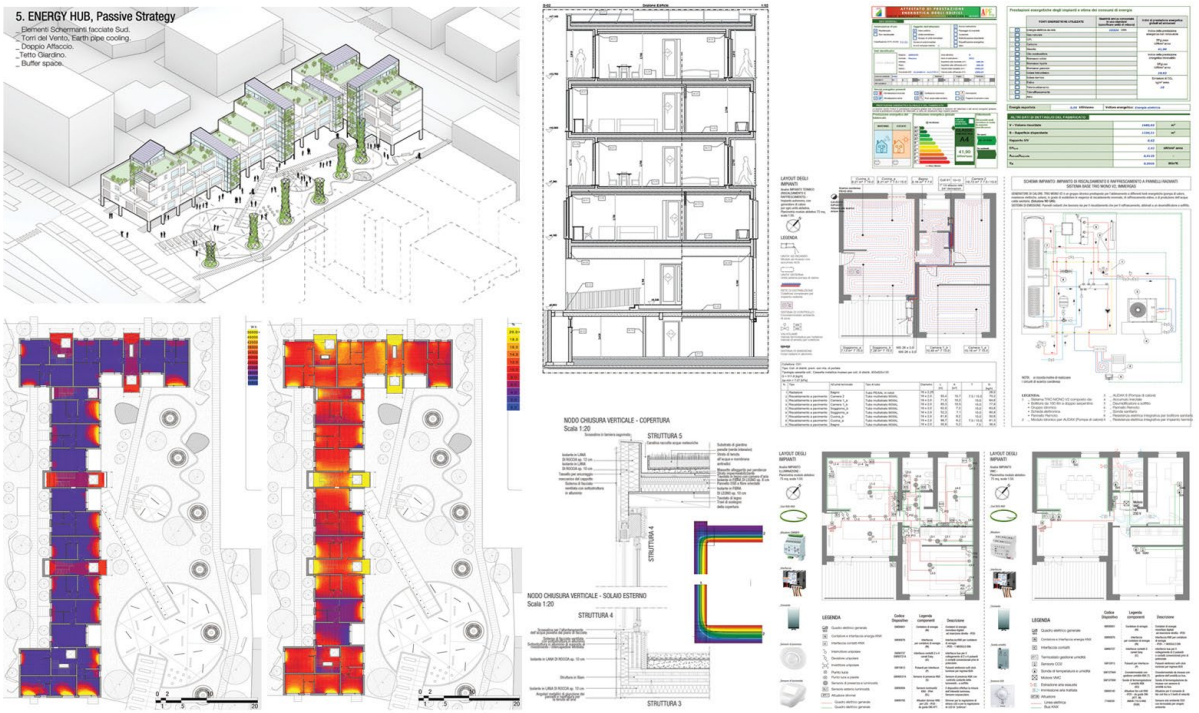
BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Student project example



Source: Extract from project tables, part of the analysis and simulations, used to defining and evaluate the urban solution (student work Davide Morelli, Master Edition 2023)

Fig. 2 – Student project example



Source: Extract from project tables, part of the analysis and simulations, used to defining and evaluate the building energy systems solution (student work Caterina Gregori, Master Edition 2021)

2024, Editorial Universitat Politècnica de València BY-NC-SA

Supported by professors, students can deal with different aspects in the same time or go back and forward about detailed conditions, selecting solutions from different points of view and argued by simulations data.

To obtain a well ordered and coherent development of the student projects, a well structured time program is required in which the main features of the projects are planned by professors in advance. All the student projects follow an integrated workflow, organised to never separate different design issues concerning different disciplines. In this way, students can realise the variety of aspects and interactions involved and referred to their proposals. In this sense the underlying target is represented by the student's understanding of the multidisciplinary nature of the environmental design.

5. Discussion and conclusion

The current framework of this postgraduate second level master's degree, focused on the strengthening of a full integrated design process, is quite recent. From the experience of the past editions, started from 2009, only in the last three years, the described teaching method has been completely defined and applied and it's still a work-in-progress. Authors are convinced of the potential to mix and overlap as much as possible different topics, disciplines and aspects to find a deeper integration in the environmental design (Warburton, 2003) (Altomonte et al., 2014). Evaluating and reviewing the master's degree is possible to highlight remarks, barriers and limits but also some benefits and improvements. The proposed design theme, ranged from urban scale to very detailed level, is probably a bit ambitious and students sometimes complain that we cover too many topics and that they lack time for the project. The large number of tools and software would require more time and exercises to be used independently by students. In the same way, the use of many different tools needs some extra work to produce 3D models or to adapt them for a specific tool. At the end the overall workflow and the workshops are strict to ensure the overlap of design activities with lessons and tools applications, requiring students to be extremely on time in completing the different design phases.

On the positive side, the course offers certainly a very comprehensive overview of the all aspects involved. At the end of the course, students know a wide variety of possible analysis and simulations. The hard challenge to coupling design activities considering different aspects in the same time with the use of energy design tools, make students more aware about effects and consequences of design proposals under different points of view and more in general about the interdisciplinary character of the energy-environmental building design, extending their professional capabilities and ability to compare with other experts. Considering the international level of many tools, simulations and aspects taught, a broader range of case studies could be considered in future, taking into account other

BY-NC-SA 2024, Editorial Universitat Politècnica de València

countries and further climate conditions as a first step towards an international postgraduate master.

Acknowledgements

The authors would thank all students enrolled in the postgraduate master's degree: Ecosostenibilità ed Efficienza Energetica per l'Architettura, at School of Architecture of Ascoli Piceno, over the years. The authors are also grateful to the whole teaching staff of Unicam for participating in the co-creation process of the didactic programs.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Altomonte, S., Rutherford, P., & Wilson, R. (2014). Mapping the way forward: Education for sustainability in architecture and urban design. *Corp. Soc. Responsib. Environ. Manag*. 21 (3), 143–154. https://doi.org/10.1002/csr.1311.

Crutzen, P. (2005). Benvenuti nell'Antropocene. L'uomo ha cambiato il clima, la Terra entra in una nuova era, Mondadori, Milan. ISBN 8804537302

Dunn, J., Van Den Wymelenberg, K., & McKibben, S. (2013). Using Building Simulation to Teach High Performance and Integrated Design. *ASEE Annual Conference & Exposition 2013*. http//doi.org/10.18260/1-2--22692

EEA. (2018) National climate change vulnerability and risk assessments in Europe 2018, *Office for Official Publications of the European Union*, Luxembourg

Figliola, A. (2018). The role of didactics in the post-digital age, *AGATHÓN International ournal of Architecture, Art and Design*, 3, 29–36. http//doi: 10.19229/2464-9309/342018.

Iommi, M. (2014). Design support for early design strategies towards near zero energy buildings. *Constec 2014 Architectural research findings: building construction, management, technology*, 1, 371-374. http//doi.org/10.1016/j.egypro.2017.03.015

IPCC. (2023). Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change. *Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge

Kincheloe, J. L. (2008). Knowledge and Critical Pedagogy: An Introduction, Springer. http//doi.org/10.1007/978-1-4020-8224-5

Naboni, E., Havinga L. (2019). Regenerative Design in Digital Practice: A Handbook for the Built Environment, Eurac Research, Bozen-Bolzano. http//doi.org/10.1007/978-1-0716-0684-1_303

Pedersen Zari, M., Connolly, P., & Southcombe, M. (2020). Ecologies Design: Transforming Architecture, Landscape and Urbanism, Routledge Earthscan, Oxon. https://doi.org/10.4324/9780429279904

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Ramirez, K. G., Bandera, C. F., & Gallardo, D. E. (2023). Leveraging digital twins for teaching environmental management and building design: case-based method approach. *16th annual International Conference of Education*, 13(2), 1215-1223. http//doi.org/10.21125/iceri.2023.0401

Warburton K., (2003). Deep learning and education for sustainability. *International Journal of Sustainability in Higher Education*, 4(1), 44–56. https://doi.org/10.1108/14676370310455332

Zhigang, S., Jensen, W., & Wentz, T. (2012). Teaching Sustainable Design Using BIM and Project-Based Energy Simulations. Education Sciences, 2(4), 136-150. https://doi.org/10.3390/educsci2030136

BY-NC-SA 2024, Editorial Universitat Politècnica de València

EnerGPT – Enhancing Energy Literacy Education by Customizing ChatGPT

Thimo Schulz[a], Kim K. Miskiw[a], Christina Speck[a] and Christof Weinhardt[a]

[a]Karlsruhe Institute of Technology, Germany

Abstract

The escalating climate crisis and economic pressures underscore the critical need for enhanced energy literacy. As the concept of energy literacy is broadly defined and hardly palpable for individuals, we align the energy literacy dimensions of knowledge, attitude, and behavior with the multifaceted household energy literacy model. Based on this tangible, yet robust construct, this paper introduces EnerGPT[1], a custom Generative Pre-trained Transformer (GPT), designed to elevate household energy literacy among individuals. Based on inquiry-based learning theories the model is equipped with specific datasets and knowledge tailored to household energy literacy education and features adhering to best practices for chat-based educational systems. These include personalized learning experiences, motivational elements, multimodal content delivery, and interactive learning activities. An initial evaluation by energy domain experts highlighted EnerGPT's potential in providing valid content, motivating user engagement, and addressing the need for concise, multimodal educational material. While the study acknowledges limitations such as limited access to custom GPTs and the absence of a structured energy literacy curriculum, it opens avenues for future research in applying generative AI in educational contexts. EnerGPT represents a significant step towards utilizing AI for fostering energy literacy, aligning with inquiry-based learning theories and adapting to users' knowledge and needs. This approach not only contributes to the field of AI-driven education but also plays a crucial role in preparing individuals to navigate and contribute to a sustainable energy future.

Keywords: ChatGPT; Energy Literacy; Education; Inquiry-Based Learning.

[1] Accessible at https://chat.openai.com/g/g-lvbucPM2Z-energpt (requires ChatGPT Plus)

How to cite: Schulz, T.; Miskiw, K. K.; Speck, C. and Weinhardt, C. (2024) EnerGPT – Enhancing Energy Literacy Education by Customizing ChatGPT. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 52-61. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The urgency of addressing the climate crisis is increasingly recognized as a pivotal challenge. This necessitates a profound transformation in our energy consumption, touching every aspect of society, as covered by the sustainable development goals (SDGs) (UN DESA, 2023). The most palpable challenge is the transformation needed in the household sector. Not only does this sector account for 28 % of the energy consumption in the EU making it a crucial area for changes induced by individuals, (Eurostat, 2023), but in the context of notably inflation and rising energy prices, the attention of individuals is also shifting towards their energy consumption. Similarly, energy poverty has been highlighted as a potential challenge for the upcoming decades (González-Eguino, 2015; Streimikiene and Kyriakopoulos, 2023). In this context energy literacy is not merely an academic concept but a practical tool for empowering individuals and communities to make informed decisions about energy use, also referred to as household energy literacy (van den Broek, 2019).

In-line with the fourth SDG (UN DESA, 2023), new avenues for education and public engagement, also in the context of household energy literacy, were opened by the advent of generative AI tools, particularly ChatGPT. The concept of a "custom Generative Pretrained Transformer (GPT)" (OpenAI, 2023) takes this a step further, allowing for the creation of specialized AI models tailored to specific domains and use cases, such as enhancing energy literacy. While hallucinations are an issue of generative AI models (Zuccon et al. 2023), these custom GPTs can be equipped with ground-truth data to counteract this. Additionally, they can easily be updated with new information which is especially important in the face of the evolving diversity of energy generation and storage devices, that individuals are confronted with, e.g., balcony photovoltaic systems or smart meters. This allows for a consistent education application that grows with its demands.

While there are few works shedding light on the usage of conversational agents for energy efficiency, energy feedback, or energy saving (Fontecha et al., 2019; Giudici et al., 2023; Gnewuch et al., 2018), the use of generative AI for energy literacy education is currently unexplored. To address this gap, we explore the development and application of a custom GPT model designed to enhance household energy literacy among individuals. Based on the literature surrounding inquiry-based learning and design elements for educational conversational agents (ECAs), we draw general conclusions for the customisation of ChatGPT models. By leveraging the capabilities of generative AI in energy literacy education, we aim to contribute to the broader efforts in promoting sustainable energy practices and addressing the challenges posed by the climate crisis and economic pressures.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Foundations

2.1 Energy Literacy and Household Energy Literacy

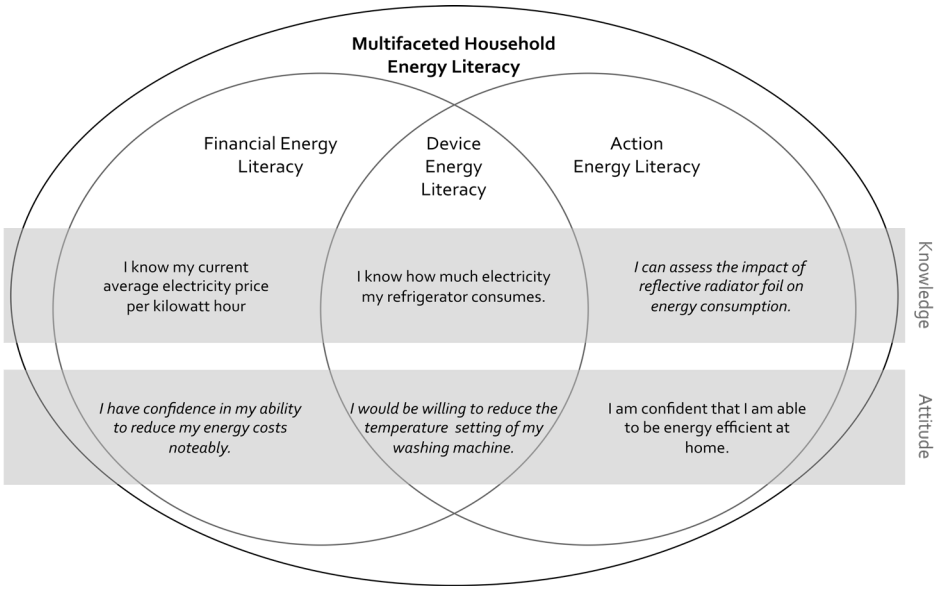
Integrating energy literacy into education is particularly crucial for building awareness and supporting government programs in national energy conservation (Rohmatulloh et al., 2021). Moreover, studies found that energy literacy levels are only moderate across all educational fields, among others natural and environmental sciences, or life sciences and health (Martins et al., 2019). This suggests the need for an enhanced approach in energy education to achieve higher levels of literacy, which is also in-line with the UN's SDG 4 (UN DESA, 2023).

Different works have come up with diverging definitions for energy literacy. While there are definitions that focus on a rather specific aspect of energy literacy, e.g., financial literacy (Blasch et al., 2018) or economic aspects (Brounen et al., 2013), DeWaters and Powers (2011) present a holistic approach towards energy literacy entailing the dimensions of knowledge, attitude, and behaviour. However, this broad concept is not easily addressable. Exemplarily, Lee et al. (2015) revealed a notable discrepancy between affect and behaviour, indicating that knowledge alone may not lead to responsible energy use.

To tackle this problem of poor tangibility for individuals, van den Broek (2019) define a multifaceted household energy literacy, composed of the concepts of financial energy literacy, action energy literacy, and their intersection device energy literacy. Regarding the concept of action energy literacy, Akitsu and Ishihara (2018) uncovered that awareness of consequences is a powerful predictor for linking basic energy knowledge to energy-saving behaviour. Bluhm et al. (2023) also conclude that for a behavioural change the energy self-efficacy of an individuum needs to be strengthened. Thereby, energy self-efficacy equals the confidence in the personal capabilities to change behaviour (Bandura, 1977). Bluhm et al. (2023) contribute a measurement instrument dedicated towards household energy literacy.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 1 – Intersection of household energy literacy (van den Broek, 2019) with knowledge and attitude dimensions (DeWaters and Powers, 2011) matched with exemplary questions based on Bluhm et al.(2023)



Source: Own elaboration

To combine both approaches, namely the three-dimensional model by DeWaters and Powers (2011) and the multifaceted household energy literacy model by van den Broek (2019), we align these models and assign the questions from Bluhm et al. (2023) to the intersections (cf. Fig. 1). As the behaviour dimension must be observed in real-life settings, we drop this dimension for our model. As not all intersections are directly targeted by the questionnaires proposed by Bluhm et al. (2023), we complement the intersected model with questions that specifically address these aspects, which are marked as cursive.

2.2 ChatGPT and Generative AI in Education

The advent of ChatGPT and generative AI has brought new educational avenues to existing learning theories, such as self-directed learning and heutagogy (Canning, 2010; Blaschke, 2012; Susnea, 2023), and especially inquiry-based learning (Avsec and Kocijancic, 2014; Cooper, 2023). Inquiry-based learning describes the process where learners educate themselves by critically questioning and exploring topics to come up with an understanding of the learning subject. Pedaste et al. (2015) provide a flexible inquiry-based learning framework consisting of 5 phases, namely orientation, conceptualization, investigation, conclusion, and discussion. Additionally, Ramandanis and Xinogalos (2023) provide an extensive list of design elements for ECAs. To enable a learning experience that covers all stages of the inquiry-based learning framework, we integrate these design elements as described in the following chapters.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Approach

To leverage the potential of generative AI, especially ChatGPT for increasing household energy literacy, we utilize the newest ChatGPT feature, namely custom GPTs. Custom GPTs refer to a new class of GPTs developed by OpenAI, designed to be more specialized and adaptable to specific tasks or industries compared to their predecessors (OpenAI, 2023). These GPTs can be fine-tuned or tailored using specific datasets. This customization enables the models to generate more accurate, relevant, and context-specific outputs, enhancing their utility in specialized fields. To generate a GPT for energy literacy education, we first define what aim in educating we pursue. Following the intersected energy literacy model in chapter 2.1 we aim to enhance knowledge concerning financial, device, and action energy literacy on a knowledge and attitude scope. Therefore, we guide the learning experience with the enriched questionnaire from Bluhm et al. (2023). Afterwards, we employ the design suggestions for ECAs by Ramandanis and Xinogalos (2023), to ensure that the GPT adheres to best design practices. Since instructions are given to custom GPT models in a loose setting, the second phase of our approach involves a concise evaluation, from which the feedback was implemented. For a first evaluation of EnerGPT, we asked three independent researchers from the energy domain to thoroughly test it. They identified three main points for improvement, which are already considered in the instructions and resources described in the following chapter. First, EnerGPT's answers were too long and overwhelming. Second, EnerGPT struggled to create a multimodal learning experience, mainly due to a small data basis and lacking emphasis on data visualization. Lastly, EnerGPT but also ChatGPT in general seem to fail to clearly distinguish the terms of energy and electricity.

4. Building EnerGPT

To build EnerGPT – our custom GPT for educating energy literacy – we first thoroughly screened the design suggestions for ECAs by Ramandanis and Xinogalos (2023) to create a list of relevant requirements. As they extracted extensive design suggestions through a literature review, we focus on those that are mentioned in at least three publications.

We build EnerGPT by finetuning and modifying ChatGPT. Aligning ChatGPT's functionalities with the design suggestions by Ramandanis and Xinogalos (2023) shows that some of the most popular design elements for ECA's are present in standard ChatGPT applications. However, to fully exploit the potential for inquiry-based learning, further refinements are necessary to comply with the ECA design elements. Table 1 gives an overview of the design elements and their incorporation in ChatGPT and EnerGPT.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Design elements for ECAs (Ramandanis and Xinogalos, 2023) and their presence in ChatGPT and EnerGPT

Design elements inherently present in EnerGPT through ChatGPT	Design elements additionally added to EnerGPT
(1) Equipment of the ECA with many variations for phrases with the same meaning. *(2) Capability to discuss wide range for discussion topics including casual, non-educational subjects.* *(3) Utilization of previous students' responses to improve its conversational ability and provide personalized communication.* *(4) The ECA should provide feedback to students.* *(5) Alignment of the ECA's function with the ethics policies and rules for the protection of the user data.*	*(6) Alignment of the ECA's function with students' learning needs.* *(7) The ECA should provide educational material in small segments with specific content.* *(8) Provision of motivational comments and rewarding messages to students.* *(9) Utilization of human-like conversational characteristics such as emoticons, avatar representations and greeting messages.* *(10) Explanation of the educational material from various perspectives.* *(11) Handling of quizzes, tests, or self-evaluation material.* *(12) Provision of challenging and interesting student learning activities.* *(13) Provision of educational material in various forms apart from text message.*

Source: Own elaboration

4.1 Instructions and design elements

To further fine-tune EnerGPT we added custom instructions to match the design suggestions. Regarding design elements *(6)* and *(7)*, we see *learning needs* from two perspectives. On the one hand, meaning that an ECA should streamline the conversation to focus on the topic, and our defined learning aims in chapter 3. On the other hand, we understand learning needs as the necessity to adapt the learning experience to the knowledge of the user. To achieve this, EnerGPT assesses its users' knowledge based on their answers and *adapts the conversation*. Furthermore, EnerGPT is instructed to provide *brief, to-the-point answers*, expanding on topics when the user shows interest in more detailed information. This method allows for a more personalized and effective learning experience, gradually enhancing the user's understanding of energy topics in an interactive manner.

As ChatGPT is proficient in theories and practice of motivation and learning (Susnea, 2023), we found it sufficient to instruct EnerGPT to keep the conversation going and provide a pleasant and efficient learning by sticking to suitable *motivation and learning theories*. Thereby, we employ design element *(8)*. In addition to the *human-like conversational characteristics* that are already implemented in ChatGPT, at the start of each new interaction,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

EnerGPT shortly introduces itself and its purpose to meet *(9)*. ChatGPT is inherently able to illuminate topics different points of view. For design element *(10)*, EnerGPT is set to explain energy-related educational material from *various perspectives*, encompassing scientific, environmental, economic, and societal aspects, to enhance comprehensive energy literacy tailored to different individual backgrounds following Martins et al. (2019) findings.

Furthermore, EnerGPT leverages *gamification elements, like quiz questions*, to foster motivation and learning and comply with *(11)*. This is in line with the implementation of *(12)*, as activities are diverse and inclusive, catering to different learning styles and interests, and ultimately foster critical thinking, problem-solving skills, and a deep understanding of the subject matter. In addition to quizzes, the ability of ChatGPT's Code Interpreter allows us to equip EnerGPT with the functionality to visualize data to create a multimodal learning approach as highlighted by design element *(13)*, especially for historical values, statistics, and trends. To use this feature, we equipped it with additional resources as listed in the following.

4.2 Additional resources

In addition to the instructions, we provide EnerGPT with resources to gather knowledge from and to deliver more streamlined and valid information and learning. To supply EnerGPT with an established definition and depiction of energy literacy, we provide it with the research paper by Martins et al. (2019). In doing so, we ensure that the conveyed energy literacy learning is in line with findings from scientific studies. To use a validated question set for gauging users' household energy literacy, we add to EnerGPT's knowledge the items proposed by Bluhm et al. (2023), as well as the newly created questions to match the intersected model as shown in Fig. 1. To create a database for visualizations and a multimodal learning experience, we feed EnerGPT statistical data from Eurostat regarding electricity prices and their components, as well as energy consumption by type of fuel and per capita (Eurostat, 2024). For this data, preprocessing is necessary in order to allow an effective usage through EnerGPT, as custom GPT applications need clean data sheets for their analyses.

5. Conclusion

Overall, we equipped custom GPTs with knowledge and instructions to enhance household energy literacy. For this we leverage the current literature on energy literacy and intersected different literacy models to define the educational aim of the custom GPT. To ensure an effective inquire-based learning environment we assessed the needed design elements and the inherent coverage of them by ChatGPT. By implementing the not covered design elements, we showcase the adaptability of custom GPTs to provide such a learning environment. The generated custom GPT – EnerGPT – for enhancing household energy literacy holds the potential for individuals to educate themselves on the highly relevant topic of energy and sustainability in an interactive and motivating way. This aligns with existing

2024, Editorial Universitat Politècnica de València BY-NC-SA

learning theories and further allows the adaptation of content and complexity on user's knowledge and learning needs. The preliminary results show that the content that EnerGPT provides is generally valid and is motivating and pushing its users to dig deeper into the topic.

Thereby, this study contributes to the current research efforts of leveraging generative AI technology for educational purposes. Moreover, it sheds light on generative AI as an effective tool for energy literacy enhancement. This study also opens interesting avenues for future work. EnerGPT does not follow a clear energy literacy curriculum but emphasizes on inquiry-based learning. While there is not one single unified energy literacy curriculum, we see it as useful to enhance EnerGPT with a clearer learning path. Moreover, in the next steps EnerGPT should be tested in a real-world setting with individuals seeking to increase their energy literacy. In doing so, we see great potential of furthering the understanding of generative AI for education, and more specifically for household energy literacy.

Acknowledgements

We gratefully acknowledge funding by the Federal Ministry of Education and Research (BMBF) and the Ministry of Science, Research and the Arts (MWK) of Baden-Württemberg (Grant No.: 16DHBKI004).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Akitsu, Y., & Ishihara, K. (2018). An integrated model approach: Exploring the energy literacy and values of lower secondary students in Japan. *International Journal of Educational Methodology*, *4*(3), 161-186.

Avsec, S., & Kocijancic, S. (2014). Effectiveness of inquiry-based learning: How do middle school students learn to maximise the efficacy of a water turbine. *International Journal of Engineering Education*, *30*(6), 1436–1449.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological review*, *84*(2), 191.

Blasch, J., Boogen, N., Daminato, C., & Filippini, M. (2018, May). Empower the consumer! Energy-related financial literacy and its socioeconomic determinants. *CER-ETH - Center of Economic Research at ETH Zurich*, *Working Paper*, *18*, 289.

Blaschke, L. (2012). Heutagogy and lifelong learning: A review of heutagogical practice and self-determined learning. *The International Review of Research in Open and Distributed Learning*, *13*(1), 56–71.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Bluhm, S., Staudt, P., & Weinhardt, C. (2023). Ensuring energy affordability through digital technology: A research model and intervention design. *Wirtschaftsinformatik 2023 Proceedings*, *43*.

Brounen, D., Kok, N., & Quigley, J. M. (2013). Energy literacy, awareness, and conservation behavior of residential households. *Energy Economics*, *38*, 42–50.

Canning, N. (2010). Playing with heutagogy: Exploring strategies to empower mature learners in higher education. *Journal of Further and Higher Education*, *34*(1), 59–71.

Cooper, G. (2023). Examining science education in chatgpt: An exploratory study of generative artificial intelligence. *Journal of Science Education and Technology*, *32* (3), 444–452.

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, *39* (3), 1699–1710.

Eurostat. (2023). Energy statistics - an overview. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview (accessed on 31.01.2024).

Eurostat. (2024). Energy database. https://ec.europa.eu/eurostat/web/energy/database (accessed on 02.02.2024).

Fontecha, J., González, I., & Salas-Seguín, A. (2019). Using conversational assistants and connected devices to promote a responsible energy consumption at home. *Multidisciplinary Digital Publishing Institute Proceedings*, *31*(1), 32.

Giudici, M., Crovari, P., & Garzotto, F. (2023). Leafy: Enhancing home energy efficiency through gamified experience with a conversational smart mirror. *Proceedings of the 2023 ACM Conference on Information Technology for Social Good*, 128–134.

Gnewuch, U., Morana, S., Heckmann, C. S., & Maedche, A. (2018). Designing conversational agents for energy feedback. *Proceedings of the DESRIST 2018*, 18–33.

González-Eguino, M. (2015). Energy poverty: An overview. *Renewable and Sustainable Energy Reviews*, *47*, 377–385.

Lee, L.-S., Lee, Y.-F., Altschuld, J., & Pan, Y.-J. (2015). Energy literacy: Evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy*, *76*, 98–106.

Martins, A., Madaleno, M., & Dias, M. F. (2019). Energy literacy: Does education field matter? *Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality*, 494–499.

OpenAI. (2023, November). Introducing gpts. https://openai.com/blog/introducing-gpts (accessed on 02.02.2024).

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47–61.

Ramandanis, D., & Xinogalos, S. (2023). Designing a chatbot for contemporary education: A systematic literature review. *Information*, *14*(9), 503.

Rohmatulloh, Hasanah, A., Syah, M., & Natsir, N. F. (2021). Energy literacy and education: The viewpoint of stakeholders to promote energy literacy in education. *E3S Web of Conferences*.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Streimikiene, D., & Kyriakopoulos, G. L. (2023). Energy poverty and low carbon energy transition. *Energies*, *16* (2), 610.

Susnea, S. M. (2023). My chatgpt teacher. towards a methodology for using artificial intelligence in self-directed learning. *Scientific Research and Education in the Airforce*, 94–97.

UN DESA. (2023). The sustainable development goals report 2023: Special edition – July 2023. *New York, USA*.

van den Broek, K. L. (2019). Household energy literacy: A critical review and a conceptual typology. *Energy Research & Social Science*, *57*, 101256.

Zuccon, G., Koopman, B., & Shaik, R. (2023). Chatgpt hallucinates when attributing answers. *Proceedings of the Annual International ACM SIGIR Conference on Research and Development in Information Retrieval in the Asia Pacific Region*, 46-51.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Stimulating Metering Applications based on Renewables Technologies: presenting the SMART project

Vasiliki Kotoula[a], Christina Panagiota Malliou[b], Evangelia Rigati[b], Georgios Chatzargyros[a], Dimitrios Stimoniaris[a] and Dimitrios Tsiamitros[a]

[a]Department of Electrical and Computer Engineering, University of Western Macedonia, Greece
[b]Renel I.K.E, Greece

Abstract

The transport sector is responsible for more than 20% of the CO_2 emissions coming from fossil fuel combustion. The car fleet is expected to grow by more than 15% by 2030, with the share of renewable energy in the transport sector the previous years being below the initial target of 14% even though the sales of electric vehicles (EVs) are constantly growing.

This paper presents the SMART (Stimulating Metering Applications based on Renewables Technologies) project that seeks to create a novel solution that will support both the transmission infrastructure and emerging demands for EV infrastructure. The project includes the development of a compact electromobility solution combining an EV charging station and a carport with an integrated energy generation system using photovoltaic (PV) modules and an energy storage system. Internet-of-Things (IoT) infrastructure along with Machine Learning (ML) based optimization models support and manage the energy consumption, generation and storage in real time, reducing the energy demand peaks due to EVs' charging.

Keywords: electromobility; renewables; energy-storage, smart-metering, Internet-of-Things.

How to cite: Kotoula, V.; Malliou, C.P.; Rigati, E.; Chatzargyros, G.; Stimoniaris, D. and Tsiamitros, D. (2024) Stimulating Metering Applications based on Renewables Technologies: presenting the SMART project. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 62-70.
https://doi.org/10.4995/SEED2024.2024.19007

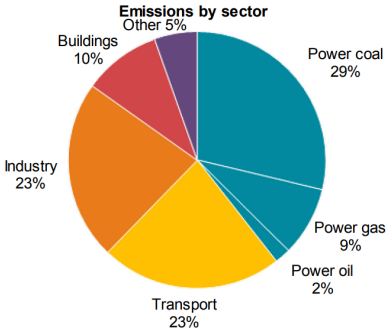
BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

One of the European goals to be achieved by 2030 is to reduce the greenhouse gas (GHG) emissions by at least 55% in comparison with the levels measured in 1990, aiming to become the first climate neutral continent by 2050. Based on the CO_2 emissions report from the International Energy Agency (International Energy Agency, 2023), in 2022 the global energy-related CO_2 emissions grew by 0.9% (321 Mt) leading to a new high of over 36.8 Gt. At the same time, emissions form energy combustion increased by 423 Mt whereas the emissions due to industrial processes decreased by 102 Mt. The global energy crisis resulted to increased emissions from coal by 243 Mt, which exceeded by far the average growth of the last decade. Moreover, emissions from oil grew even more than the emissions from coal by 268 Mt reaching a total of 11.2 Gt.

According to the International Energy Agency, the transport sector is responsible for 23% of the CO_2 emissions coming from fuel combustion, as shown in Fig. 1. Following the lift of the restrictive measures that were put in place during the COVID-19 pandemic, the energy demand in the transport sector rose by 4% while the electricity demand from the road transport was nearly 60% higher in 2022 in comparison with 2019 (International Energy Agency, 2023).

Fig. 1 - Global energy-related CO_2 emissions by sector

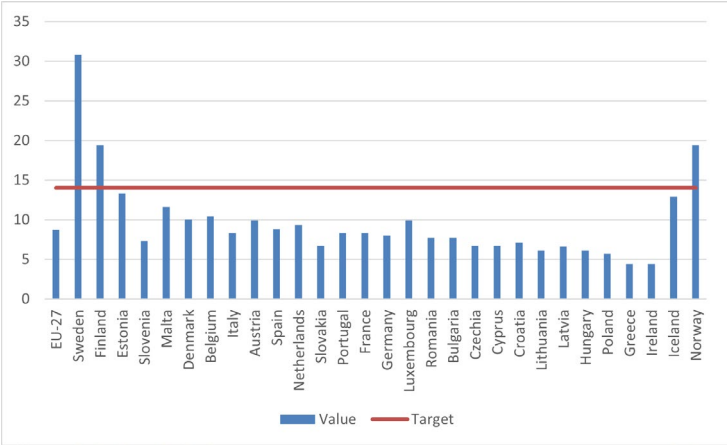


Source: IEA (2020)

With the global car fleet expected to grow by more than 15% by 2030 (International Energy Agency, 2023), the transport sector will play a key role in the energy consumption and the fossil fuel reduction, making the use of electric vehicles a key step to achieve the EU goals. However, data provided by the European Environment Agency (Statistical Office of the European Union (Eurostat), 2023) show that the share of renewable energy in the transport sector for the year 2021 was only 9.1 %, far below the initial target of 14% that was set on Article 25 of the EU Directive on the promotion of the use of energy from renewable sources (Directive 2018/2001) and the average for 2022 was even lower at 8.7%. The following figure (Fig. 2) presents the share of energy from renewable sources in the transport sector by country in 2022.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 - Renewable energy share in the transport sector by country for 2022



Source: Statistical Office of the European Union (Eurostat) (2023)

Currently, with the new EU directive in place has set more ambitious targets and the Member States have to ensure that the amount of renewable fuels and renewable electricity supplied to the transport sector will lead to a share of renewable energy within the final consumption of energy in the transport sector of at least 29% by 2030 or to a greenhouse gas intensity reduction of at least 14.5% by 2030 (Directive 2023/2413).

2. Electromobility trends

The electric vehicle market is growing exponentially. It is worth noting that the electric vehicles' sales were more than 10 million in 2022, with the 14% of the new cars sold for the year 2022 to be electric. In comparison with the previous year, 2021, the sales of electric vehicles presenting an increase by 9% (IEA , 2023). The trends recording the past years show that the electric vehicle sales will continue to grow over the next years while both the European Union and the United States have passed legislation to support and promote the use of electric vehicles. Research has shown that even though the legislation set by the government are considered a good first step towards the increased use of electric vehicles, strategic allocation of charging infrastructure will allow more users to access this technology (Geronikolos & Potoglou, 2021).

At the end of 2022, there were approximate 2.7 million public charging points worldwide. Public access to fast chargers is expected to enable longer journeys while reducing the distance barrier for the adoption of electric vehicles (IEA , 2023).

3. The SMART project

The SMART project aims at developing an innovative smart solar charging station with an integrated model that allows to manage the energy consumption and generation in real time. This will support the optimal and efficient energy management. To achieve that, IoT

2024, Editorial Universitat Politècnica de València BY-NC-SA

technologies along with ML algorithms and techniques are utilized. The developed model considers various parameters such as climatic, economic and statistical load data. The data, after successfully analysed, suggest to the station owners the optimal solution based on the current and forthcoming status. This could include storing energy generated from the RES or storing energy from the grid, sell the RES generated energy or the energy stored in the energy storage system to the grid as well as buy energy from the grid to consume it. The information is presented using a user-friendly mobile application and a web-based platform.

4. Technical analysis of the pilot system

The pilot system is located in the parking lot of a shopping centre in Thessaloniki, Greece. The charging system consists of a 9.84 kWp PV plant, mounted on a carport mounting system. The PV modules selected for this application are of monocrystalline silicon technology. The selected technology delivers superior efficiency and is considered suitable for distribution projects. Each PV module has a nominal power of 410 Wp under Standard Test Conditions (STC). As STC are considered: irradiance 1000 W/m2, module temperature 25 oC and Air Mass (AM) 1.5. The selected modules are identical (model, series, manufacturer, technical and electrical characteristics in nominal operation, geometric dimensions). The efficiency of the modules is 21.1% at nominal operating cell temperature (NOCT) and the ingress protection rating is IP68. Therefore, the modules are dust-tight, and they are protected against the effect of continuous immersion in water (International Electrotechnical Commission, 2013). Each module has a maximum system voltage of 1500 Vdc and they are able to operate in a wide range of ambient temperatures ranging from -40 °C up to 85 °C, with a mechanical load endurance up to 5400 Pa for front side loads. The temperature coefficient of the maximum power (Pmax) is -0.34% /°C (LONGi, 2022). Each module consists of 108 silicon cells, connected in series and in parallel, enclosed in an aluminium profile frame. To achieve the desired power, 24 PV modules are required, with the selected placement of the PV modules at the pilot site presented in Fig. 3.

Fig. 3 – Placement of PV modules at the pilot site

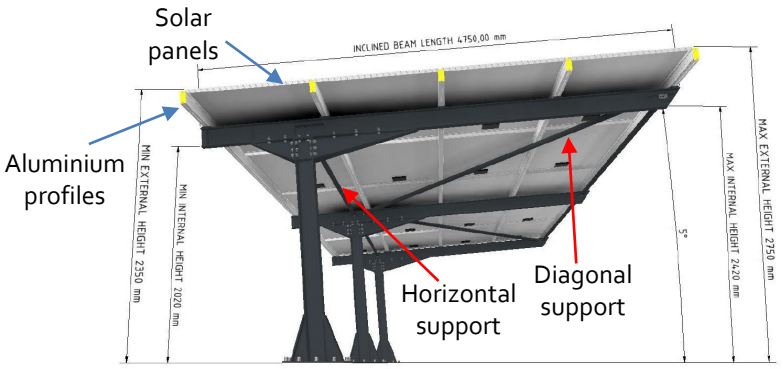


Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The PV modules are placed on the solar carport presented in the following figure (Fig. 4) using the horizontal aluminium profiles that are installed on the beams and the appropriate clamps. The solar carport, made from S-235 steel, is fixed to the ground on a reinforced concrete base. To provide increased stability to the frames, horizontal and diagonal auxiliar support beams were used, while the inclined beams ensure a 5° tilt angle. The solar carport has a maximum external height of 2.75 m and a minimum internal height of 2.02 m. The dimensions of the solar carport are also depicted in Fig. 4.

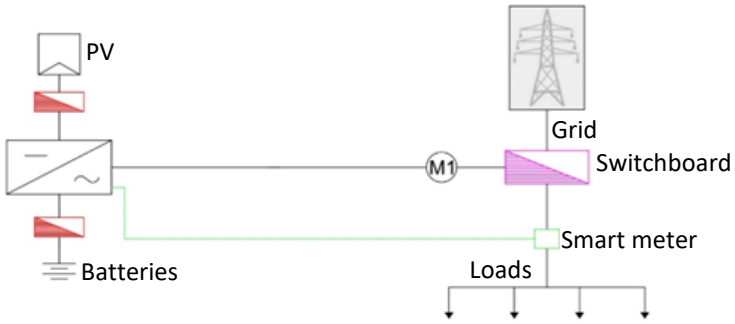
Fig. 4 – Solar carport assembly representation



Source: Own elaboration

The energy generated by the PV system can be either stored in the energy storage system or sold to the grid, depending on the energy sufficiency, the load demand and the forecasting. The connection of the PV system and the battery energy storage system (BESS) with the grid and the potential load is presented in the following figure (Fig. 5). Both the PV system and the BESS are connected to the DC side of an inverter and the output will be connected through a smart meter to the switchboard and the grid. According to the requirements of the Hellenic Electricity Distribution Network Operator (HEDNO), the generation system is not connected to the switchboard of the installation but to a point upstream.

Fig. 5 – Schematic diagram of the PV system and BESS connected to the grid and the loads

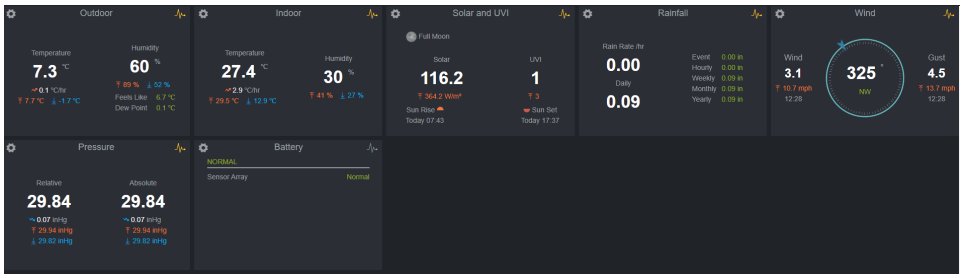


Source: Own elaboration

BY-NC-SA

The selected charging station uses a Mode 3 charging technology that allows the communication between the EV and the charger. This mode allows voltage to pass only when a suitable charging current has been determined by the EV, making the controlled charging possible. The charging process may start either automatically as soon as an EV is connected or via a develop web application. The charging station provides up to 22.2 kW using a Type 2 socket that can significantly reduce the charging time. It provides IP54 ingress protection rating and IK08 impact protection rating. It provides short circuit protection and AC/DC current leakage protection. To monitor the operation of the system, a smart power meter is installed. The selected smart power meter is a three-phase current sensor, widely used in solar power systems. It uses the Modbus Remote Technical Unit (RTU) communication protocol that enables the communication with various devices, sensors and controllers while allowing effective error handling. At the same time, the smart meter supports serial communication using the RS-485 protocol. Both protocols are widely used in a range of applications, especially in industrial environments. It is worth noting that the selected smart meter provides accuracy of +/-0.5% for voltage measurements, +/-1% for current, power and energy and +/- 0.01 Hz for the frequency. The developed IoT system takes input from a variety of sensors in real time, including the current temperature, the solar irradiation and the ultraviolet index (UVI) as well as the battery status of the EVs. Ambient conditions that could affect the operation of the system such as the wind speed are also monitored with the proper sensors. The collected data are then displayed in a developed web platform (Fig. 6), while a mobile application could also be used to access the data via a variety of mobile devices. The data displayed on the platform are updated automatically in 1 min time intervals. The collected data are also stored for historical purposes and could be used to create graphical representations and for trends' analysis or could be viewed in a tabular format. Although most of the required metrics are collected by the developed IoT system and the installed sensors, some parameters such as the duration of stay are requested as user input to determine the users' needs.

Fig. 6 – Web platform for data visualization



Source: Own elaboration

Following the literature review (Efthymiou et al., 2017), (Agarwal et al., 2016), ((Lazari and Chassiakos, 2023), (Majidpour et al., 2014), the proposed IoT model was developed to take

BY-NC-SA 2024, Editorial Universitat Politècnica de València

into consideration various demand response schemes analysing incentives based real-time pricing (RTP), critical peak pricing (CPP) and time of use (ToU). The algorithm used calculates the available energy from the battery energy storage system, the available charging time based on the users' input and the desired charging rate. In addition to this, the algorithm determines if energy from the PV systems should be stored or sold to the grid. The stored energy could also be sold to the grid based on the current cost of energy, the weather conditions and the users' requirements. The proposed flowchart is presented in Fig. 7. To evaluate the performance of the proposed flowchart three different cases were considered: basic charging where the EV is charged up to 100% and then the charging process stops, cost management charging where the charger selects the lowest electricity rates to charge the EV and sells the surplus energy from the PV and the BESS to the grid and the optimised charging following the proposed algorithm. The results showed that the proposed algorithm during the pilot's operation allowed to sell energy to the grid when the prices were high, while providing at least the desired level of charging to the EVs.

5. Conclusion and future work

The SMART project deploys a robust, replicable and scalable methodology to support the development of a sustainable and smart mobility sector. The IoT approach that takes into account the user requirements, the current state of the vehicle, the current and forthcoming weather conditions as well as the current energy prices, allowing to take advantage of the low energy prices to charge the vehicles if needed while selling surplus energy to the grid in periods where the energy prices are high. During the pilot operation of the system, the results showed that the proposed algorithm was able to provide the necessary level of charging or even more, in full alignment with the users' requirements. At the same time, in periods with high energy prices, the proposed algorithm was able to either sell energy to the grid, lowering the overall energy cost or to use energy from the energy storage system based on the forecast and the current status of the system. The studies conducted as a part of the SMART project offer valuable insights to support the development of the future charging infrastructure, generate and promote knowledge sharing and allow future training for the professionals of this rapidly growing sector. The proposed methodology will be further tested in various locations to ensure that the system's behaviour will remain the same in different weather conditions and time periods. This will facilitate the uptake of EVs while taking into consideration the potential impact of the EV charging in the grid.

Acknowledgements

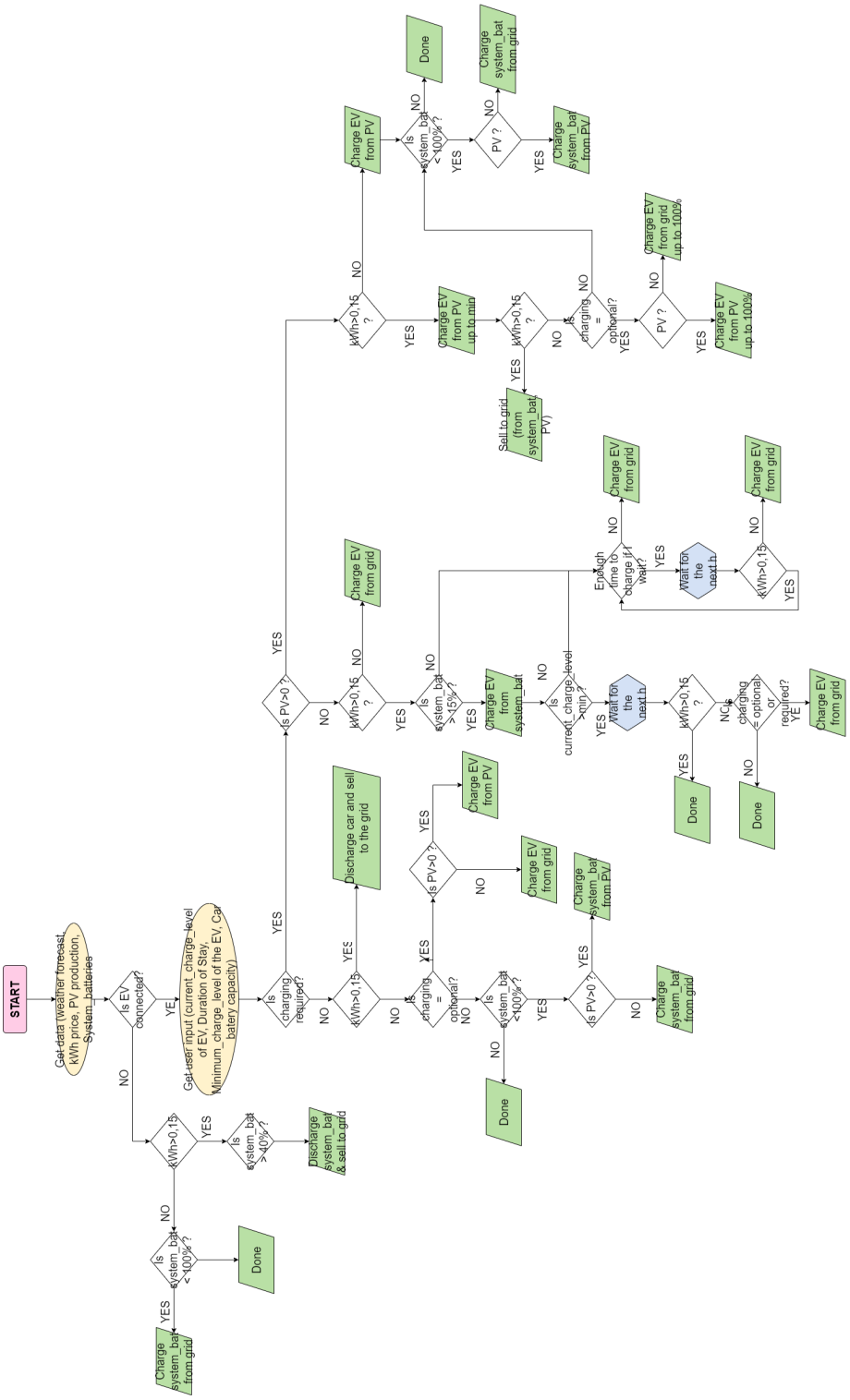
The SMART project is supported by a grant from Iceland, Liechtenstein and Norway through the EEA Financial Mechanism 2014-2021, in the frame of the Programme "Business Innovation Greece" (2021/580998).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Fig. 7 – Proposed flowchart



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Agarwal, P., Pan, J., & Victor, W. (2016). An Efficient Algorithm for Placing Electric Vehicle Charging Stations. *27th International Symposium on Algorithms and Computation (ISAAC 2016)* (pp. 7:1--7:12). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik.

Directive 2018/2001. Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

Directive 2023/2413. *Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council .*

Efthymiou, D., Chrysostomou, K., Morfoulaki, M., & Aifantopoulou, G. (2017). Electric vehicles charging infrastructure location: a genetic algorithm approach. *European Transport Research Review*.

Geronikolos , I., & Potoglou, D. (2021). An exploration of electric-car mobility in Greece: A stakeholders' perspective. *Case Studies on Transport Policy*, 906-912.

IEA . (2023). *Global EV Outlook 2023.* https://www.iea.org/reports/global-ev-outlook-2023.

IEA. (2020). *The role of CCUS in low-carbon power systems.* Paris. https://www.iea.org/reports/the-role-of-ccus-in-low-carbon-power-systems.

International Electrotechnical Commission. (2013). Degrees of protection provided by enclosures (IP Code). *IEC 60529:1989+AMD1:1999+AMD2:2013*.

International Energy Agency. (2023). *CO2 Emissions in 2022.* Paris. https://www.iea.org/reports/co2-emissions-in-2022.

International Energy Agency. (2023). *World Energy Outlook 2023.* Paris. https://www.iea.org/reports/world-energy-outlook-2023.

Lazari , V., & Chassiakos , A. (2023). Multi-Objective Optimization of Electric Vehicle Charging Station Deployment Using Genetic Algorithms. *Applied Sciences*, 13(8):4867.

LONGi. (2022, January 21). Hi-Mo 5m LR5-54HPH 400~420M. *20220121DraftVo.3_AU datasheet*.

Majidpour, M., Qiu, C., Chu, P., Gadh, R., & Pota, H. (2014). A novel forecasting algorithm for electric vehicle charging stations. *2014 International Conference on Connected Vehicles and Expo (ICCVE)*, (pp. 1035-1040).

Eurostat. (2023, September 25). *Share of energy from renewable sources*. Retrieved from European Environment Agency: https://www.eea.europa.eu/data-and-maps/data/external/share-of-energy-from-renewable-sources-2

2024, Editorial Universitat Politècnica de València BY-NC-SA

Teaching and Learning of Renewable Energy in Remote and Dispersed Pacific Islands

Sekove Vodo[a] and Ramendra Prasad[a]

[a]Department of Science, School of Science and Technology, The University of Fiji, Fiji

Abstract

The Pacific Small Island Developing States are grappling with climate mitigation opportunities largely due to a lack of capacity. The teaching and learning of renewable energy courses in these countries is challenging due to its geographically dispersed islands, compounded by the COVID-19 pandemic. The University of Fiji moved on to the Hyflex mode of learning and teaching of post-graduate Renewable Energy Programmes since then and is continuing this journey post-pandemic. This paper looks at the student experiences of learning renewable energy courses. A questionnaire was answered by 21 graduate students online, with 85.7% agreeing to flexibility in the learning schedules from the Hyflex mode. The outcomes of the student survey with detailed analysis explore the benefits and opportunities that this modality of learning and teaching offers. The insights could be used for future course developments, remote teaching, and learning of Renewable Energy Programmes and sustainable education opportunities.

Keywords: renewable energy courses; Pacific; Hyflex teaching; SIDS; Fiji.

How to cite: Vodo, S. and Prasad, R. (2024) Teaching and Learning of Renewable Energy in Remote and Dispersed Pacific Islands. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 71-78. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Renewable energy (RE) holds significant promise for addressing environmental challenges and fostering sustainable development, particularly in remote and dispersed regions. The Renewable Energy Programmes (REPs) are one of the key drivers to improve the economy by fostering environmental awareness and promoting the adoption of clean energy solutions leading to improvements in social and environmental aspects. Even the Organisation for Economic Co-operation and Development (OECD) countries have found a positive correlation between renewable energy education (REE) and cleaner energy solutions (Zafar et al., 2020). In a recent study, Vakulchuk and Overland (2024) found that even though the need for RE professionals is greater in developing countries, developing countries lag behind developed ones in this area.

In the Pacific Small Island Developing States (SIDS), the economic vulnerability stemming from a persistent heavy reliance on imported fossil fuels has prompted a growing interest in RE initiatives. Batra and Norheim (2022) highlighted the untapped renewable resources from solar, wind, hydroelectric, tidal, geothermal, and biomass in SIDS but noted that institutional strengthening, including training, continues to be an important area of concern for SIDS governments. The issue of a lack of training of personnel in REPs is compounded by challenges in social acceptance of renewable energies in SIDS, the geographically dispersed nature of the SIDS, and labor mobility. Fiji also has the potential for enhanced RE, however is not immune to these challenges. In the case of Fiji, in the last 3 years, post-Covid19 over 84,598 people migrated for work purposes overseas in 2023 alone and improper handover of information due to this brain drain has been alarming (Boila, 2023).

Amidst these challenges, this research delves into the imperative role of teaching and learning in shaping the landscape of RE adoption in these geographically isolated island nations. With University of Fiji (UniFiji) offers REPs including Postgraduate Diploma in Energy and Environment (PGDEEN) and Master of Science in Renewable Energy Management (MScREM) to students in Fiji and the SIDS. Students learn about the technologies, the critical role of trust, community acceptance, policy makers' endorsement, and investors' confidence in the successful implementation of any RE projects. These PGDEEN and MScREM, programs are offered through the Hyflex mode of teaching allowing academics to provide significant levels of elevated knowledge and support to students, thus offering a nuanced understanding of the factors influencing RE projects in social acceptance in a SIDS. Khan (2020), identified a link between REE and social aspects, as well as REE and the environment in his study of solar home systems. REPs promoted community engagement and participation in sustainable energy initiatives, leading to improved social cohesion and economic development. REPs can empower individuals to make informed decisions about energy consumption and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

conservation, thereby contributing to environmental preservation (Urmee and Mohammed,2016).

2. Research Methodology

The study aimed to explore the perspective of postgraduate students on the teaching and learnings from the REPs offered at UniFiji through the remote e-learning mode called Hyflex. This mode refers to an educational approach that gives the students the liberty to choose between attending classes in person or participating in online platforms or virtual classrooms. Survey questions were strategically designed. The responses were collated via Google Forms sent to 81 students who have taken REPs courses at UniFiji from 2020 to 2024 (Table 1) whereby only 21 responses were received. The research was conducted in compliance with ethical standards and the analysis was performed on the responses received. The data collected were completely anonymous; the test results were also classified.

Table 1 – Number of students in Renewable Energy Programmes (2020-2024)

Renewable Energy Programs	Number of Students
PGDEEN	54
MScREM	28

Source: Own elaboration

3. Results and discussions

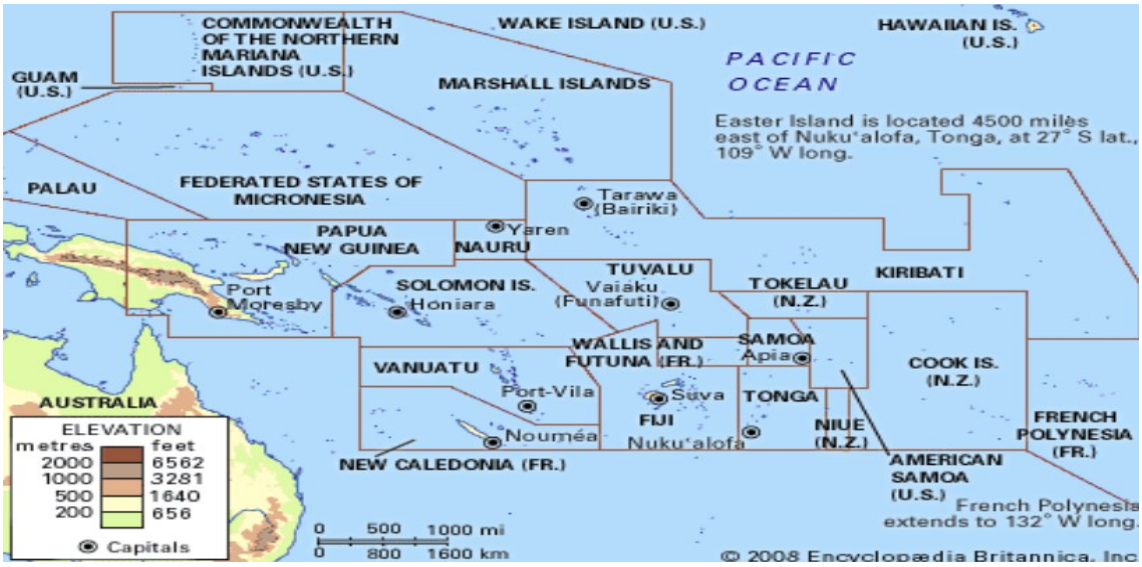
The survey revealed that before COVID-19, 42.9% of the REPs students traditionally attended evening classes at the UniFiji campus (Table 2). With the introduction of the Hyflex mode during COVID-19, REPs have continued to be offered in the mentioned mode to the Pacific SIDS. Online delivery of courses was introduced way before COVID-19, as during the occurrence of the H1N1 influenza virus and Hurricane Katrina the classes were switched to online delivery mode (Gamage et al., 2020).

Out of the three tertiary institutions in Fiji, only UniFiji offers specialized REPs at the graduate level. All programs at UniFiji have now (post-COVID-19 pandemic) switched back to in-person attendance of classes or face-to-face delivery mode except for the graduate REPs. One of the main reasons was that through Hyflex modality greater geographical reach and increased penetration of REPs to other Pacific SIDS was possible. Fig. 1 shows the geographical locations of the Pacific SIDs to provide a context. The archipelago of Fiji alone has over 300 islands distributed over 1.3 km^2 of vast ocean, of which 110 islands are permanently inhabited. Fiji has two main larger islands called Viti Levu and Vanua Levu where most of the cities and universities are concentrated.

Hence, within Fiji, the students were geographically scattered with 85.7% agreeing to flexibility in the learning schedules (Fig. 2). Also, 66.6% of the surveyed students stated that

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 1 – Map of the Oceania region, including countries in the South-West Pacific



Source: Britannica Encyclopaedia, https://www.britannica.com/place/Pacific-Islands.

online delivery allowed them to access education from their remote locations if they had internet access and a device. The Internet network coverage is an issue as the telecommunication company, Vodafone, caters to 78% of the mobile market in the two main islands while Digicel covers the rest of the 32% through their 3G services including the small isolated islands (Horst & Foster, 2024). To ameliorate this, students from outer smaller islands must find the best spot for good internet reception to attend the online teaching sessions.

With the Hyflex mode of REPs, the influence of the online teaching sphere has changed with students within the Pacific SIDS opting to stay in their home countries, without the need to

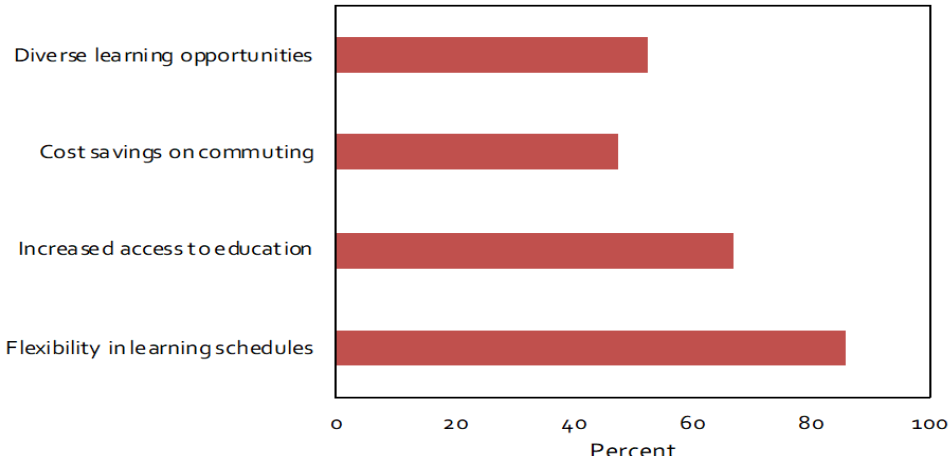
Table 2 – Socio-Demographic Characteristics of Surveyed Students

Socio-Demographic Characteristics of Surveyed Students	
Age	**Number (%)**
20-30	3 (14.3 %)
30-40	10 (47.6%)
40- 50	7 (33.3%)
50 - 60	1 (4.8%)
Gender	
Male	17 (81.0%)
Female	4 (19.0%)
Timeframe of Pursing the Programmes	
Before COVID-19	9 (42.9%)
During COVID-19	6 (28.6%)
After COVID-19	6 (28.6%)

Source: Developed by authors

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 – Benefits of continuing Hyflex mode



Source: Developed by authors.

take study leave from work or travel to other countries. The survey revealed that 19% of students in UniFiji's REPs were from New Zealand, Cook Islands, Solomon Islands, and Vanuatu, which was not possible in the in-person delivery mode. In addition, working students found it comfortable to upgrade their qualifications with graduate-level REPs as there were 47.6% of the respondents were between the age of 30-40 while 33% were between 40-50% (Table 2). These students came with vast experiences or are current practitioners in RE fields or otherwise prompting for flipped classroom methodology of learning.

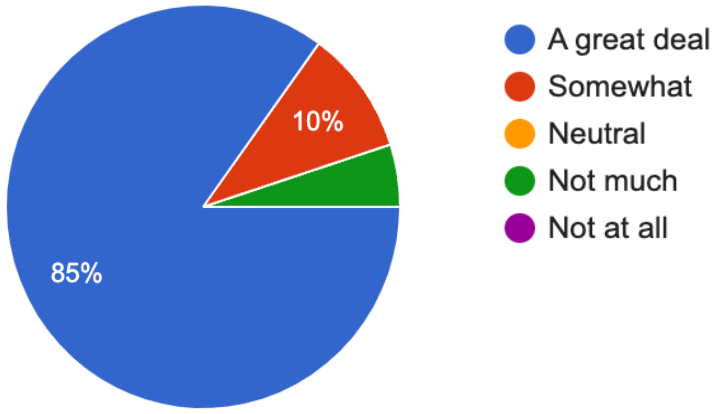
While the global energy sector has traditionally been male-dominated, the same trend has been observed locally with 81% of the respondents being male (Table 2). A notable feature was a slight increase in number of female students enrolled in REPs to 3 from the yearly average of 1 student (Table 2). This could be attributed to the safer learning approach whereby students do not have to rush to campus after work or return home late at night after class. While breaking the gender barrier will be challenging, it is expected to contribute to the availability of qualified professionals. According to Assali et al. (2019), female students tend to have a higher awareness level regarding the use of solar energy and RE in Palestine. Thus, it is important that REE approaches be continually reviewed to make it gender inclusive and will also be aligned with the National Energy Policy for 2023-2030, on gender equity and equality of opportunities in REE (Republic of Fiji, 2023).

The provision of REE in SIDS could contribute to the availability of a well-trained human resources pool enabling large-scale development and deployment of RE technologies in developing countries (Ciriminna et al., 2016). In addition, educating politicians, media professionals, and project developers on REE has garnered interest from managers with non-engineering backgrounds applying as graduate students. This agrees with more than 70% of the survey respondents that REE influences a person's willingness to adopt RE practices (Fig.

 BY-NC-SA

3). These practices could be solar panels on rooftops for residential or commercial buildings, solar-powered appliances, and gadgets or even solar water heating systems among others.

Fig. 3 – Benefits of continuing Hyflex mode



Source: Developed by authors

Hosseini et al. (2018) found that in Pakistan, wind energy had a better social acceptance than solar and geothermal energy but highlighted the importance of increasing knowledge levels of residents for developing RE. Hyflex mode of education and awareness about the environmental benefits of RE is important in fostering public acceptance of RE initiatives.

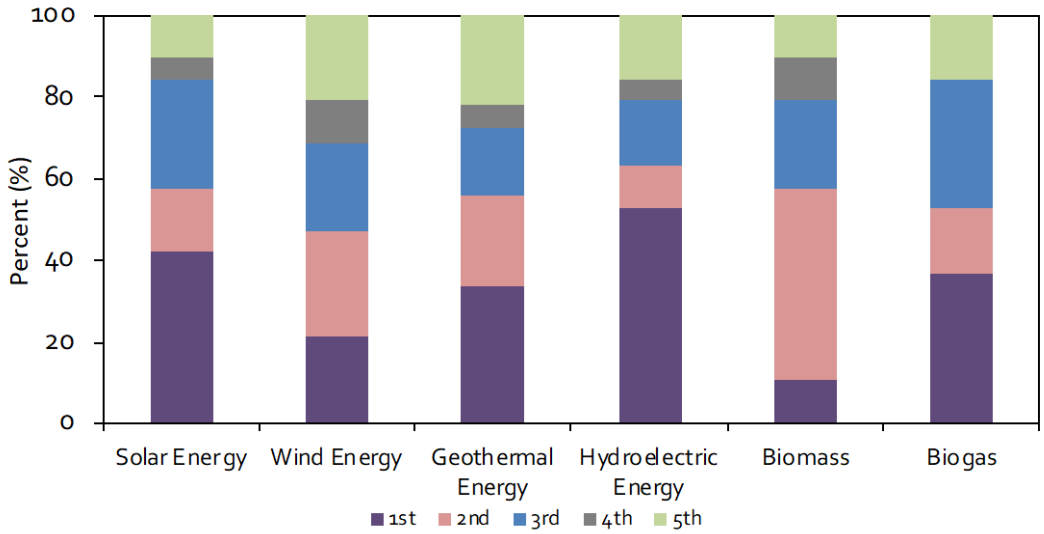
However, Pacific SIDS is still highly dependent on imported fossil fuels with 20% making up the total imports, leading to economic vulnerability (Republic of Fiji, 2023). It therefore creates an enabling environment for accessing donor funding for RE in the region. Currently, about 57% of Fiji's grid electricity is generated from RE sources, largely hydro. Intriguingly, 52% of the surveyed students supported this by ranking hydroelectric energy, as the most socially acceptable RE source (Fig.4). With that, 47% also rated solar energy as the most accepted source of RE in Fiji, followed by biomass as the second most RE source, biogas as the third, with wind and geothermal as the least socially acceptable RE source.

Promoting REE to increase its social acceptability is important to drive the transformational change that is envisioned by SDG7. The visibility of graduate REPs at UniFiji and the Pacific region is further enhanced by international projects and collaborations such as the Transforming Energy Access-Learning Partnership (TEA-LP) project. The addition of the TEA-LP course on *Energy Access Solutions and Microgrid Design* to UniFiji's current graduate REPs will boost the students' approach to learning RE on a much more holistic approach. In addition, enhanced industry-academic educational cooperation and collaborations are necessary, such as the MOU between UniFiji and Dawn Renewable Energy (Fiji) Ltd, to promote RE innovations and industry-driven research. It also provides an opportunity for REP graduates, to analyse the energy situation, develop energy savings, and examine the energy flow for local applications within Fiji and the Pacific (Ciriminna et al., 2016). REPs are carefully

BY-NC-SA 2024, Editorial Universitat Politècnica de València

made available as digital copies for lectures and tutorials with video recordings as well. So, the course has central availability of RE information through digital technologies as an intelligent and flexible solution to maximizing graduates' performance.

Fig. 4 – Ranking of Renewable Energy in Terms of Social Acceptance



Source: Developed by authors

4. Conclusion

Pacific SIDs have a challenging environment for the delivery of REPs delivery as students are located in remote and isolated locations across geographically dispersed islands due to their work schedules. Innovative and flexible teaching and learning approaches such as remote Hyflex e-learning are necessary for the delivery of REE for these isolated locations in Pacific SIDS, to increase REE access and for increased social acceptability. The REPs at UniFiji have gained interest from managers with non-science backgrounds indicating the critical need to improve awareness and understanding of RE. Moreover, UniFiji has amassed an elevated potential to deliver high-quality REE within the region since its recognized partnerships with local and international stakeholders. It ensures that relevant skills and knowledge imparted through REE are continually appreciated.

Acknowledgments

This work is based on data and knowledge obtained in 2024, a research project supported by the TEA-LP. The authors thank all the partner institutions, sponsors, and researchers in the delivery of the Renewable Energy Programmes.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València BY-NC-SA

References

Assali, A., Khatib, T., & Najjar, A. (2019). Renewable energy awareness among future generation of Palestine. *Renewable Energy*, 136, 254-263. https://doi.org/10.1016/j.renene.2019.01.007

Batra, G., & Norheim, T. (2022). Staying Small and Beautiful: Enhancing Sustainability in the Small Island Developing States. In *Transformational Change for People and the Planet: Evaluating Environment and Development*, 73-91. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-78853-7_6

Boila, S. (2023 August 5). Labour migration surpasses 8,000 this year alone. *FBC News*.

Ciriminna, R., Meneguzzo, F., Pecoraino, M., & Pagliaro, M. (2016). Reshaping the education of energy managers. *Energy Research & Social Science*, 21, 44-48. https://doi.org/10.1016/j.erss.2016.06.022

Gamage, K. A., Wijesuriya, D. I., Ekanayake, S. Y., Rennie, A. E., Lambert, C. G., & Gunawardhana, N. (2020). Online delivery of teaching and laboratory practices: Continuity of university programmes during COVID-19 pandemic. *Education Sciences*, 10(10), 291. https://doi.org/10.3390/educsci10100291

Horst, H. A., & Foster, R. J. (2024). 5G and the digital imagination: Pacific Islands perspectives from Fiji and Papua New Guinea. *Media International Australia*, 1329878X231199815. https://doi.org/10.1177/1329878X231199

Hosseini, A., Zolfagharzadeh, M. M., Asghar Sadabadi, A., Aslani, A., & Jafari, H. (2018). Social acceptance of renewable energy in developing countries: challenges and opportunities. *Distributed Generation & Alternative Energy Journal*, 33(1), 31-48. https://doi.org/10.1080/21563306.2018.11969264

Khan, I. (2020). Impacts of energy decentralization viewed through the lens of the energy cultures framework: Solar home systems in the developing economies. *Renewable and Sustainable Energy Reviews*, 119, 109576. https://doi.org/10.1016/j.rser.2019.109576

Republic of Fiji. (2023). National Energy Policy 2023 - 2030.

Urmee, T., & Mohammed, A. (2016). Social, cultural and political dimensions of off-grid renewable energy programs in developing countries. *Renewable Energy*, 93, 159-167. https://doi.org/10.1016/j.renene.2016.02.040

Vakulchuk, R., & Overland, I., (2024). The failure to decarbonize the global energy education system: Carbon lock-in and stranded skill sets. *Energy Research & Social Science*, 110, 103446. https://doi.org/10.1016/j.erss.2024.103446

Zafar, M. W., Shahbaz, M., Sinha, A., Sengupta, T., & Qin, Q. (2020). How renewable energy consumption contribute to environmental quality? The role of education in OECD countries. *Journal of Cleaner Production*, 268, 122149. https://doi.org/10.1016/j.jclepro.2020.122149

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Digital educational tool on energy efficient retrofitting of buildings

Jose Alberto Díaz[a], Silvia Soutullo[a], Emanuela Giancola[a] and Maria Nuria Sánchez[a]

[a] Energy Efficiency in Buildings R&D Unit / Division of Renewable Energy, CIEMAT, Spain

Abstract

The ECF4CLIM Project aims to co-design, test, and validate an European Competence Framework for the educational community, facilitating the transition towards a sustainable and low-carbon economy. This initiative involves collaboration with schools across diverse European countries. To support this endeavor, educational and practical IT tools are being developed within a digital platform, including the Retrofitting Toolkit. The toolkit's purpose is to raise awareness of energy efficiency among stakeholders in the educational community, with its primary objective being to encourage engagement and promote behavioural changes towards efficiency and sustainability.

The Retrofitting Toolkit incorporates various features designed for different user levels, including students, teachers, staff and families. The toolkit encompassess climate assesments, a building energy performance database to quantify energy savings resulting from retrofitting measures, and visualization tools to aid in the design of energy-saving retrofits for buildings.

It operates through two sequential tools, enabling a comprehensive analysis of energy efficiency improvements. The first tool assesses climate trends and suggests passive and active measures tailored to various educational centres. The second tool estimates building thermal requirements and quantifies the energy savings. This approach empowers the educational community to actively contribute to the collective goal of establishing environmentally sustainable and energy-efficient schools.

Keywords: Sustainability; Education; Building Refurbishing; Energy Efficiency; Digital Tools.

How to cite: Diaz, J.A ; Soutullo, S.; Giancola, E. and Sánchez, M.N. (2024) Digital educational tool on energy efficient retrofitting of buildings. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. . 79-87. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The current climate situation and the projected scenarios for the future emphasize the need to integrate sustainability and energy efficiency at all levels of our society. In this context citizens behaviour is a key aspect (Vainio, 2020). This makes education and training assume particular significance, as it allows to obtain a sustainiblity culture (Gamarra, 2019). It is essential to equip the educational community with the knowledge, skills and attitudes required to achieve a more equitable, efficient and sustainable society (Bianchi, 2022).

From this standpoint, a new European Competence Framework (ECF) should be designed to provide the educational community with tools and guidelines that facilitate this transition. In response to this necesity, the European project ECF4CLIM has emerged, with its primary objective being to develop, test and validate a new ECF that supports educational communities in adopting sustainable measures to combat climate change. This new ECF is crafted through a multidisciplinary, transdisciplinary and participatory process, encompassing social, digital and STEM-related competencies that interact with each other. The applied methodology systematically explores individual, organizational, and institutional factors that either enable or limit the desired change.

In response to the identified needs of the educational comunity through dialogues with the stakeholders, a Digital Platform has been designed to serve as a space for interaction among different actors. The ECF4CLIM platform emerges as a comprehensive ecosystem addressing challenges related to climate change through a multifaceted approach. With a focus on participation and education, the platform seamlessly integrates four principal components that collectively contribute to a comprehensive strategy for climate action. These components include Crowdsourcing, Simulators Space, IoT Ecosystem and Learning Space. The Simulators Space functions as a gateway for applications within the ECF4CLIM platform, aggregating three tools tailored to assess and enhance environmental sustainability in educational settings: Environmental Footprint Calculator, Retrofitting Toolkit and Sustainability Interventions Evaluation.

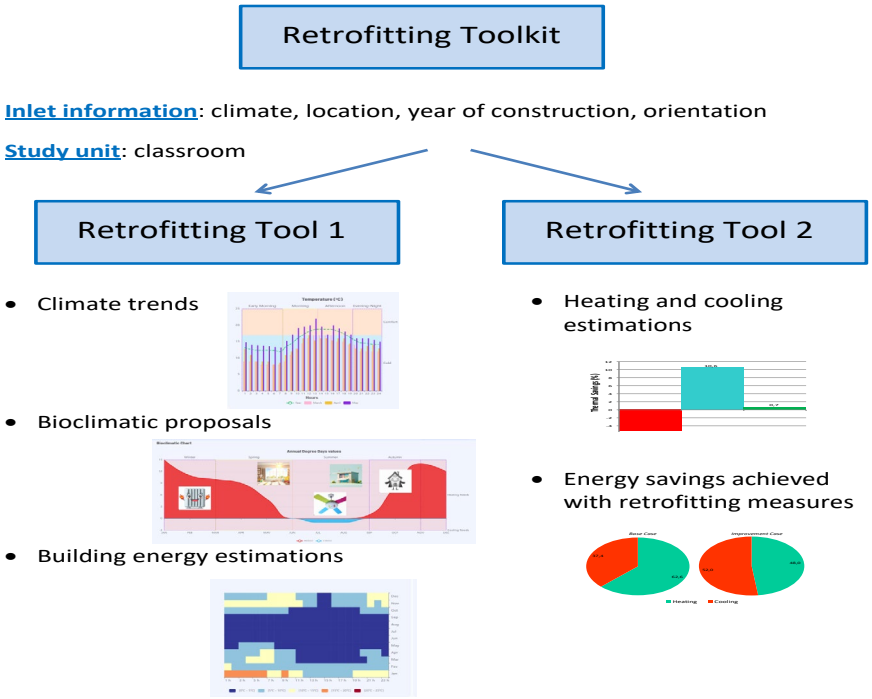
The energy used for air-conditioning in buildings is a significant portion of overall consumption and a major source of pollution (IEA, 2021). Reducing these patterns requires education at all stages. Environmental education in schools can improve household electricity use (Gill, 2028). Students show moderate awareness of renewable energy, which should be emphasized (Atluntas, 2018). Energy performance assessment tools for schools have potential with minimal data input (Lizana, 2017). Therefore, the development of web tools is of great interest for educational and decision-making purposes. This article describes the capacities of the Retrofitting Toolkit created in this Simulation Space, highliting the developed methodology and the generated outputs.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. Methodology

The design of a building under energy efficiency and sustainability criteria depends on different factors, including climatology, urban layout, volume, construction variables, windows, dimensions and materials of shading elements, and the typology and use of buildings (Pacheco, 2012). The ultimate objective is to achieve high levels of comfort inside these buildings by managing exposure to solar radiation, utilizing winds efficiently, and modulating temperature and humidity. Diagrams and maps of climatic and energy characteristics are essential elements used to facilitate efficient and sustainable buildings design. These graphical representations depict environmental properties and heating and cooling requirements, enabling the quantification of indoor thermal comfort levels.

Fig. 1 – Scheme of the methodology used for the development for this Retrofitting Toolkit



Source: CIEMAT (2024)

The Retrofitting Toolkit is developed to assess the building energy performance, offering a set of valuable functionalities for understanding the climate trends of an area and the energy requirements of a building. The process begins with the selection of inlet information that feeds the toolkit. Key inputs include the location of the educational center, climate data (Energy Plus climate databases), year of construction of the building, and orientation . The unit of analysis is a representative classroom. Two tools are defined according to the outputs generated. Tool 1 is fed by climate data and set point temperatures; resulting in climatic maps, identification diagrams of passive and active measures for energy retrofitting of the classroom, and graphs estimating the heating and cooling needs. On the other hand, Tool 2 is fed by climate data, year of construction of the building and its orientation; allowing for the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

dynamic quantification of the energy efficiency of classrooms through simulation tools (TRNSYs Energy simulator fed with constructive values from Spanish regulations). Figure 1 shows the methodological scheme developed to carry out this Retrofitting Toolkit.

3. Results

The Learning Space is specifically designed to offer a diverse range of educational resources aimed at increasing awareness of climate change and fostering sustainable development. It comprises dedicated sections for teachers and students at various educational levels, ranging from elementary and secondary to university levels. The Teacher's Section provides assistance with digital content and resource links.

Whitin the toolkit, there is a specialized tool designed to evaluate the energy savings resulting from the implementation of various retrofitting measures. These features collectively contribute to a comprehensive and effective approach within our platform to enhance the energy efficiency of structures. Users, through these retroffiting tools, can select input data for each school, analyze the climatic characteristics of the area, identify various measures to enhance thermal comfort within schools, estimate heating and cooling requirements based on established set points, and quantify the thermal needs of a classroom by considering the suggested energy efficiency measures.

3.1 Tool 1

This first tool is developed to provide climate and bioclimatic information of each school location based on the Energy Plus weather files. The tool consists of three sections: a) Climate maps; b) Bioclimatic strategies adapted to the climate zone of the school; and c) Heating and cooling estimation. For each climate input, the first two sections show static results while the third shows dynamic results.. In this tool, students have the ability to analyze diverse environmental variables, including temperature, relative humidity, global solar radiation, wind speed, and temperature in different cities. This analysis extends not only across different cities but also varies throughout the day and across the seasons.

The tool has been designed with distinct access profiles based on the user's educational level distinguishing between teachers and students. For students, there are three access levels categorized as Primary, Secondary, and University. Both the tool's usability and the displayed outputs are adapted to the educational level of the user, with complexity varying accordingly. For users with primary and secondary profiles, their exploration is somewhat limited, as they can only access data for their own city. At the primary level, users can select the variable they wish to analyze from four options (temperature, relative humidity, global solar radiation and wind speed), each represented by suggestive icons. They can then analyze the fluctuations in these variables throughout various seasons. The tool illustrates potential strategies for

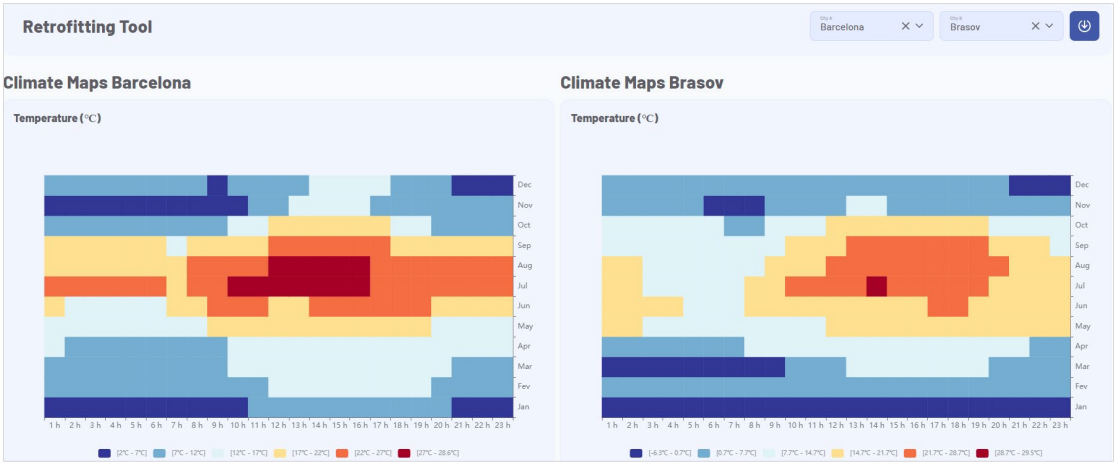
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

achieving thermal comfort within the building, with icons like the radiator indicating heating activation or the window icon suggesting the utilization of direct solar radiation. The complexity of the graphs presented at the primary and secondary levels is intentionally adjusted to suit the age group and educational level of these users. The graphs are crafted to be both understandable and engaging, providing valuable insights into the variations of environmental factors over time.

As users progress to the secondary, university and teacher levels, the capabilities of the platform expand. At these higher levels, users can examine data for multiple cities simultaneously. This functionality enables comparisons between different locations, fostering a deeper understanding of how environmental variables behave across diverse geographical areas. Notably, the graphs become more intricate at these levels, offering a greater depth of information and analysis. This complexity is intentional, designed to challenge users and encourage a more advanced exploration of the subject matter.

As an example, the functionalities available through the tool at the university level are showcased. At the university and teacher levels, the initial visualizations depict climograms for each variable over the 24 hours of the day and the 12 months of the year. The primary objective is to highlight distinctions and similarities among various climatic zones (Fig.2), facilitating a more profound understanding for the users.

Fig. 2 – Comparing temperature climograms of two different cities (teachers and university levels)



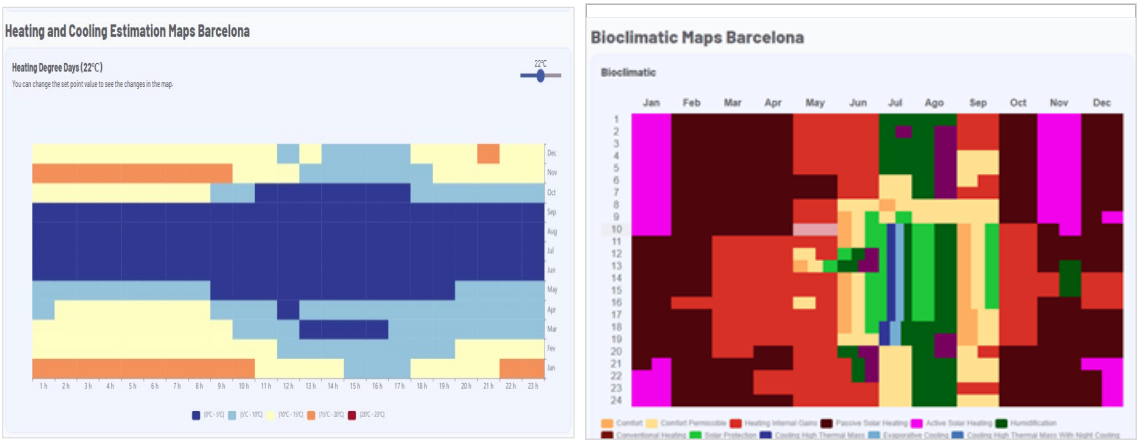
Source: Own elaboration

Heating and cooling degree days for the two selected zones are also displayed, with the option of selecting and adjusting the reference temperature used to calculate these thermal requirements (Fig.3a). In addition, static maps specific to each location are visualized, illustrating the suggested bioclimatic strategies for each hour and month (Fig. 3b).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

These maps delineate up to fourteen zones, corresponding to twelve bioclimatic design strategies tailored to the climatology of the area. The implementation of these strategies aims to achieve an optimal sensation of thermal comfort within schools.

Fig. 3 – a) Heating degree days and b) Bioclimatic diagrams (teachers and university levels)



Source: Own elaboration

Beyond providing users with a comprehensive annual overview of bioclimatic strategies, they also have the flexibility to select and visualize specific strategies of interest. This interactive feature enables users to pinpoint the ideal hours and months on the graph where these strategies would best contribute to thermal comfort. This personalized approach enhances the user's capacity to comprehend and apply the most suitable techniques based on their specific needs and preferences.

The Retrofitting Calculator offers a progressive learning experience. It begins with a focused exploration for primary and secondary users within their own city, incorporating considerations of seasonality. As users progress to the university and teacher levels, they gain the capability to compare data across different cities, accompanied by more intricate graphs that align with their higher level of expertise. This advanced information empowers users to compare not only selected variables across different cities but also variables within the same city or across multiple cities. The primary objective is to highlight differences and similarities among different climatic zones, fostering a deeper understanding for the student. Users can additionaly tailor their experience by selecting specific value ranges for display on the map, enriching their interactive learning journey.

3.2 Tool 2

This tool is developed to evaluate the energy-saving potentials achieved by implementing different retrofitting measures in schools. The tool collects initial building information, queries the simulation database available, and quantifies the retrofitting percentage reached by the selected measure. The use of this tool allows estimating the energy response of a

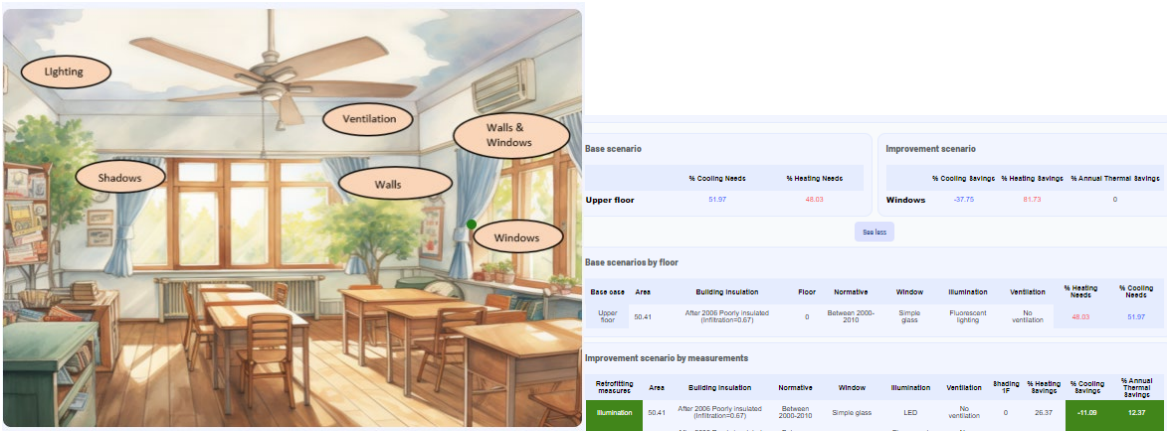
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

representative classroom when different retrofitting measures are implemented. The analyzed data is sourced from TRNSYS Energy Simulator, incorporating building parameters from Spanish regulations and the same climatic data as Tool 1.

Similar to Tool 1, in Retrofitting Tool 2 there are different access levels in the platform: Primary, Secondary, University, or Teacher. At the Primary level, users can select their school from a list of all Primary level schools. After choosing a representative image of the selected school, users can further select the classroom floor (upper, middle, or lower). Following the selection of the floor level, users are redirected to a new window that presents a visual representation of a classroom. Upon entering the page, cooling and heating needs for the selected school and floor's base scenario are presented. Users can choose an improvement measure from the following options: shadows, walls, illumination, ventilation, windows and the combination of walls and windows.

After choosing an improvement option, the selected item is highlighted, and the data regarding the implemented improvement becomes instantly accessible. Cooling and heating savings, along with the annual thermal savings, are displayed. Detailed information about the configurations of the base and improvement scenarios is also provided.

Fig. 4 – Retrofitting toolkit 2 visualization



Source: Own elaboration

At the secondary level, on the initial screen, the user must not only choose the floor but also select the classroom orientation: North, South, East, West. Regarding the selection of improvement scenarios, everything is defined in the same way as in the primary level. The difference lies in the visualization, where the energy savings results are presented in the form of a graph rather than a table.

At the university level, in order to enhance students' learning experiences, users have the freedom to choose potential base cases for each city without restrictions. Additionally, the system facilitates a more efficient comparison of various chosen rehabilitation measures, streamlining the assessment process. Once a location is chosen, several predefined base

BY-NC-SA 2024, Editorial Universitat Politècnica de València

cases area available for the user to select. Each of these cases includes a fixed common part corresponding to predetermined variables as well as user-selected variables: number of external facades, Classroom Orientations, Floor and area. To select improvement scenarios, users at the university level can choose multiple improvements. For each option, the user can choose between no change and the proposed improvement.

As of April 2024 the tools are available online, with Tool 1 completed and Tool 2 being finalised. Training courses specialized in the use of both tools are being conducted for teaching staff, taking into account the academic level at which they teach

4. Conclusions

The main goal of this Retrofitting Toolkit is to actively engage students, teachers, and educational staff in the awareness and decision-making process regarding climate change and energy efficiency in buildings. To achieve this objective, two tools have been designed to be user-friendly and visually instructive, facilitating the participation of different users within the educational community.

The Retrofitting 1 tool equips all users with the ability to assess various meteorological variables such as temperature, relative humidity, global solar radiation and wind speed throughout the day and year. It also provides annual and seasonal heating and cooling degree days, indicating the requirements needed for thermally conditioning the classroom based on outdoor temperatures and set point temperatures. For the university and teaching level, this tool displays an annual diagram highlighting hourly bioclimatic strategies to achieve optimal levels of thermal comfort sensation inside the classrooms.

Retrofitting Tool 2 is designed for diverse educational levels, providing a user-friendly interface and comprehensive features to evaluate and compare retrofitting measures in school buildings. It aims to assess energy-saving potential of retrofitting in schools. Users, categorized by Primary, Secondary, University or Teacher level, can select their educational center, analyze classroom cooling and heating needs, and efficiently assess the impact of rehabilitation measures. Results are presented graphically for a greater understanding based on the student's level. At the university level, users can evaluate information from various educational centers, defining specific circumstances for the base case they want to assess. This enhances flexibility and variability in comparing retrofitting measures. The system provides predefined base cases with common and user-selected variables, allowing users to select multiple improvements and choose between no change and proposed improvements.

Both tools are user-friendly and applicable to the school buildings involved in the project and their local climate. They provide clear and easy-to-interpret graphs and data at several educational levels, enabling the assessment of the actual impact of simple implementation changes and the benefits of retrofitting strategies on indoor environment.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036505. The authors would like to thank the European Commission for funding the ECF4CLIM project, within the Horizon 2020 - Research and Innovation Program call under grant agreement No. 101036505.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). GreenComp The European sustainability competence framework. In Punie, Y. and Bacigalupo, M. (Eds.), EUR 30955 EN, Publications Office of the European Union, Luxembourg. ISBN 978-92-76-46485-3.

ClimACT project. Transition to a low carbon economy in schools. http://www.climact.net/

Gamarra, A.R., Herrera, I., Lechón, Y. (2019). Assessing sustainability performance in the educational sector. A high school case study. STOTEN, 692, 465-478.

Gill, C., Lang, C. (2018). Learn to conserve: the effects of in-school energy education on at-home electricity consumption. Energy Policy, 118, 88-96.

International Energy Agency, (2021), World Energy Outlook 2021, IEA, Paris

ECF4CLIM - An European competence framework for a low carbon economy and sustainability through education. https://www.ecf4clim.net/

ECF4CLIM Retrofitting Toolkit 1: https://ecf4clim-app.smartwatt.net/app/retrofitting-tool-1

ECF4CLIM Retrofitting Toolkit 2: https://ecf4clim-app.smartwatt.net/app/retrofitting-tool-2

Lizana, J., et al. (2017). Energy assessment methodology towards low-carbon energy schools applied to Mediterranean buildings. En 12th Conference on Sustainable Development of Energy, Water and Environment Systems. SDEWES 2017. Dubrovnik.

Pacheco, R., Ordóñez, J., Martínez, G. (2012). Energy efficient design of building: A review. Renewable and Sustainable Energy Reviews, 16(6), 3559-3573.

Vainio, A., Pulkka, A., Paloniemi, R., Varho, V., Tapio, P. (2020). Citizens' sustainable, future-oriented energy behaviours in energy transition. Journal of Cleaner Production, 245, 118801. ISSN 0959-6526.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Upskilling of automotive engineers into electric and hybrid vehicles engineers in Greece

Georgios Tsiranidis[a], Theocharis Xenitopoulos[b], Dimitrios Tsiamitros[c], Dimitrios Stimoniaris[c], Margarita Vatista[d], George Scroubelos[d], Theofano Kollatou[c], Athina Krestou[e], Ioannis Lamprakakis[c] and Andreas Maropoulos[d]

[a]INNORA Spin-off company of the University of Western Macedonia, Greece

[b]Federation of Automotive Engineers of Greece (OBEAMME), Greece

[c] Department of Electrical and Computers Engineering, University of Western Macedonia (UoWM), Greece

[d] RMS, Greece

[e] Department of Mechanical Engineering, University of Western Macedonia, Greece

Abstract

The automotive sector is undergoing a significant transition towards electric and hybrid vehicles (EV/HV), necessitating the upskilling of automotive engineers to adapt to this change. This paper delves into the process of enhancing the skills of traditional automotive engineers to cater to the growing demands of the EV/HV industry. Central to this research is a case study from W. Macedonia, Greece, where a synergistic effort involving the University of Western Macedonia, its spinoff INNORA, RMS-Greece, and the Federation of Automotive Engineers of Greece (OBEAMME) serves as a benchmark for aligning engineering expertise with the latest EV/HV legal standards. This study also explores the feasibility of emulating Greece's approach in other countries, evaluating the obstacles and prospects, and identifying effective practices for worldwide adoption. The results underscore the success of these upskilling initiatives in boosting workforce skills, encouraging innovation in industry, and supporting environmental sustainability. Concluding with strategic recommendations for relevant stakeholders, the paper projects the future direction of skill enhancement in the automotive field, underlining its criticality in an evolving technology-centric industry environment.

Keywords: Electric vehicles; Hybrid vehicles; Automotive engineers, Health & Safety.

How to cite: Tsiranidis,G.; Xenitopoulos, T.; Tsiamitros,D.; Stimoniaris,D.; Vatista, M.; Scroubelos, G.; Kollatou,T.; Krestou,A.; Lamprakakis,I. and Maropoulos, A. (2024) Upskilling of automotive engineers into electric and hybrid vehicles engineers in Greece. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 88-96. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The Transport and Mobility Sector emerges as a critical area of focus in the contemporary European context. The sector, not only contributes 5% to the European GDP and employs around 10 million workers, but also has a significant environmental footprint. Therefore, it is not surprising that in the contemporary European context, the Transport and Mobility sector is at the forefront of transformative changes aimed at achieving sustainable, smart, and resilient mobility (EC Fact Sheet, 2020). Actually, the Green Deal strategy has set goals like reducing transport-related greenhouse gas emissions by 90% by 2050, introducing vehicles that don't emit pollutants, and doubling the use of high-speed trains by 2030. These ambitious goals aim to change how people travel in Europe, accelerate the economy and benefit the environment and humans' health as mentioned at EC Fact Sheet (2022) and the Transport and the Green Deal (2019).

Technological advancements in the mobility sector worldwide have been accelerated over the past years, driven by the urgent need to reduce greenhouse gas emissions, the demand to eliminate the reliance on fossil fuels and the set up of supportive legislative frameworks. These advancements include the production of electric and hybrid vehicles, the market share of which being steadily increased worldwide during the last years (EC Fact Sheets, 2022). Particularly in Europe, the volume of Electric vehicles' (EV) sales increased by 15% in 2022 and gained a further 15% in 2023 over 2022, supported by a light-vehicle market recovery of 11.3% year on year (EV Volumes).

Based on the above statistics, it is obvious that the automotive industry is undergoing a monumental transformation with the advent of electric and hybrid vehicles. Consequently, the skills acquired by the professionals working in this domain should be updated to the latest needs. Upskilling is therefore not just beneficial for the automotive engineers but essential for their professional survival. As the automotive landscape changes, there is a growing gap between the skills possessed by traditional automotive engineers who are experienced in combustion engines, and those required for designing, developing, and maintaining electric and hybrid vehicles. This skills gap poses a significant challenge, revealing an industry-wide field for upskilling.

This paper briefly describes the current state of automotive engineering and the implications of the shift to electric and hybrid vehicles. Starting from a representative case study from W. Macedonia, Greece, that is presented in detail, examines how legal frameworks and educational initiatives can facilitate the transition of the automotive industry. Additionally, the paper explores the replication of this case study - Good Practice in other countries, discussing the implications and the key aspects that should be considered for the successful upskilling of people working in the automotive industry.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. State of the art

The history of automotive engineering has been marked by the development and refinement of the internal combustion engine (ICE). Over the past century, transportation has faced multiple changes as a result of improvements in internal combustion engine technology while the car industry has become a major player in the global economy and culture. However, this progress has inevitably lead to environmental degradation and resource eliminations and has forced governments to apply strict legislation related mainly to the emission of greenhouse gases.

In order for these problems to be overcome, the automotive sector has shift towards the production of electric (EV) and hybrid vehicles (HV). This transition has been enabled by advancements in battery technology, electric motors, and power electronics that made EVs and HVs more feasible and appealing. Additionally, Governments worldwide strongly support this change through incentives and regulatory measures, encouraging a more eco-friendly mode of personal and public transportation.

However, there is a significant ongoing challenge: the existing skill gap among automotive engineers. Many engineers are primarily trained in internal combustion engine (ICE) vehicles, whereas EVs and HVs require expertise in areas like high-voltage systems, battery management, and electric powertrains. This gap extends beyond technical skills to a conceptual shift, where engineers need to transition from a focus on mechanical aspects to an emphasis on electrical design and maintenance.

Numerous studies (Neill, 2020, Fix Auto USA,2019, Leon, 2023) have highlighted the urgency of upskilling initiatives in the automotive sector. These initiatives, related either to short-term training or to comprehensive educational courses, all aimed to equip engineers with the necessary competencies for EVs and HVs. Successful examples often involve collaboration between educational institutions, industry bodies, and governmental agencies, creating tailored programs that address specific needs and bridge specific gaps in the workforce.

3. Case Study in West Macedonia, Greece

3.1 Overview of the Initiative - Good Practice

In response to the evolving demands of the automotive industry, a significant upskilling initiative - Good Practice has been developed in the region of W. Macedonia, Greece. The University of Western Macedonia (UoWM), in collaboration with its spinoff company INNORA, the Health & Safety company RMS IKE-Greece, and the Federation of Automotive Engineers of Greece (OBEAMME), has developed a program to transition automotive engineers into specialists in electric and hybrid vehicles. This initiative aligns with Greece's

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

new legal framework (FEK No 3270/17-05-2023), which mandates the upskilling of automotive engineers to include expertise in hybrid and electric vehicles.

According to the aforementioned FEK, all automotive engineers in the 17 national automotive working permits should undergo 20 to 62 hours of training courses related to EVs and HVs and must successfully pass examinations to augment their working permits to include services for hybrid and electric vehicles.

Historically, the region of Western Macedonia has been recognized as Greece's "Energy Heart," contributing over 65% of the nation's electricity predominantly through lignite-fired power plants. This production significantly influenced the regional economic development, which was heavily reliant on activities associated with the Public Power Corporation S.A. of Greece. However, with Greece's transition towards renewable energy sources and the consequent decommissioning of lignite-fired plants in the region, an urgent need for the reskilling or upskilling of a substantial segment of the regional workforce emerged. In this context, the transformation of automotive engineers into specialists in electric vehicles has rapidly evolved into an exemplary practice.

3.2 Target Groups and Training Deployment

The primary target groups for this upskilling initiative included members of OBEAMME, along with Electrical and Mechanical Engineers at various educational (higher education Level 6 and 7) and professional levels (relative working permit Level 5 and below). The training programs were comprehensive, covering theoretical knowledge, practical skills, and safety measures relevant to electric and hybrid vehicles..

3.3 Training Courses and Syllabus

The courses were categorized into two main groups: Electrical and hybrid vehicles engineers Category 1 and Category 2. The syllabus encompassed a range of topics, including:

i) Types and characteristics of electric vehicle batteries, their capacity, efficiency, and thermal leakage.

ii) Safety precautions and first aid related to electric shocks.

iii) Batteries technology, inverters technology, electric machines, VCUs, NCUs, etc.

iv) Maintenance and repair procedures for hybrid and electric vehicles, including specific models like the Toyota Prius, Nissan Leaf, and VW ID.4 GTX.

The training program included theoretical instruction covering all previously mentioned subjects (Figure 1), complemented by practical experience gained through working on three distinct electric and hybrid vehicles (Figure 2). Furthermore, trainees were provided with access to an asynchronous web platform, developed by the University of Western Macedonia

BY-NC-SA 2024, Editorial Universitat Politècnica de València

(UoWM), which was designed to facilitate their preparation for the examinations. Additionally, the training was supplemented by a textbook (Figure 3), created by the training team, and distributed to all participants.

Fig. 1 – Shots from the theory and laboratory courses



Source: Author

Fig. 2– Shots from training on the vehicles



Source: Author

Fig. 3 – The book on electric and hybrid vehicles



Source: D. Stimoniaris et al (2023)

BY-NC-SA

3.4 Organizational Aspects

The organization of these courses involved meticulous planning and coordination with various stakeholders. Key steps included the preparation of educational materials, the establishment of an online platform for asynchronous education, the arrangement of training venues, and the management of logistics like catering, laboratory and equipment access. This comprehensive approach ensured a structured and effective learning environment.

The University's training center and its spin off company, INNORA, were focused on organizational aspects. INNORA handled the initial administrative tasks for each seminar, such as coordinating trainees and managing initial paperwork. Meanwhile, the university was responsible for issuing certifications and setting up e-class platform accounts for each trainee. Additionally, INNORA was in charge of designing the training curriculum and scheduling the courses throughout the seminar period.

3.5 Technical Staff and Challenges

University professors, technical staff and members from OBEAMME and INNORA comprised the team of experts that developed the courses' material and provided the corresponding training. One of the significant challenges was to schedule training for professionals who were already engaged in the field, necessitating flexible and efficient training modules.

3.6 Assessment and Scale-Up

The training programs were evaluated through anonymous feedback forms and exam success rates. The feedback was overwhelmingly positive, with high evaluation scores and an exam success rate above 88%. The success of these programs has led to a demand for their replication in other regions and for other target groups, such as highway personnel and road assistance companies.

3.7 Improvement

The developers of this GP, taking into account the wide acceptance of their GP and the current technological trends (Leon, 2023 and Firu et.al.,2021), are considering of improving this GP in the teaching and training field. Actually, they plan to extend the training topics by establishing a Health and Safety laboratory, aligning with the requirements of the corresponding FEK No 3270/17-05-2023. Additionally, they plan to develop Virtual reality tools for specific activities of EV education (e.g. removal of batteries of EVs or installation of charging points) that they intend to incorporate in the currently applied teaching methods. This later improvement will provide automotive technicians with a training platform, enabling them to hone their repair and maintenance skills in a secure and simulated setting. These simulations can replicate a variety of situations, including engine repair, electrical

(cc) BY-NC-SA 2024, Editorial Universitat Politècnica de València

system diagnostics, and collision repair work. By utilizing this technology, technicians can enhance their abilities and knowledge, ultimately leading to higher quality service and increased customer satisfaction (Firu et.al.,2021).

4. Replication in Other Countries

When replicating this GP, there are some key challenges that should be addressed in order to design successful training programs. Adaptation of training material to local industry needs and alignment to national legal requirements are two of them. The existing skills level is also a factor that should be strongly considered during the courses development. The establishment of strong collaboration among the parties involved for the development of training material, the design of flexible training modules and the elaboration of a blended learning approach combining theory, practical exercises, and online resources are factors that also should be weighed when designing the upskilling courses. Last but not least, the availability of technical expertise (trained trainers) is also crucial.

Tailoring the program to address these specific needs ensures that the upskilling GP could be both relevant and effective.

5. Results and Impact

Training programs for upskilling engineers for electric and hybrid vehicles are expected to create significant shifts in the automotive sector. Anticipated benefits include increased rates of certification exam success, a rise in the number of proficient engineers in this specialty, and enhanced employment prospects.

However, the effectiveness of these upskilling initiatives could serve as a model for workforce enhancement in other industries experiencing technological shifts. The successful implementation of the presented case study highlights the need for collaboration between industries, educational institutions and governments, in order to fill skill gaps and prepare a workforce capable of handling future technological innovations.

This collaboration can also guarantee that training programs stay pertinent and effective. All the involved parties should also invest in research and development to keep the training content updated with the latest technological breakthroughs. Additionally, it's important to advocate for policies that motivate enrollment in upskilling programs, thus securing a consistent influx of skilled engineers into the workforce.

It is noteworthy to mention that, in less than a period of 10 months, 500 engineers were trained in the Northern Greece (from Corfu until the Turkish border with Greece). The success rate during the exams is average 90 %, however, the people that did not pass have the opportunity to be examined in a short period of time, without any cost.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The growing interest among automotive engineers to participate in the training program confirms its success. This demand persists despite the program being held onsite rather than online. The primary reason for this popularity is the high quality of the seminars, which is partly attributed to maintaining them as onsite events. Additionally, the intensive practical experience offered during the seminars contributes significantly to their appeal.

6. Conclusion

This paper discusses the demand of upskilling of automotive engineers in electric and hybrid vehicles. The presented case study from W. Macedonia, Greece, which is a successful upskilling Good Practice in the corresponding field, underlines the importance of such programs in aligning the skills of engineers with the demands of modern automotive technology dictated by the transition to non-fossil fuels utilization. Legislative support, collaborative efforts between all the involved parties (industry, educational institutions, governments), the adoption of flexible and comprehensive training models as well as the availability of well trained trainers are all deemed as crucial for the success of similar programmes.

It is widely accepted that the automotive industry's shift towards electric and hybrid vehicles is expected to accelerate in the following years. This transition will continue to drive the demand for skilled engineers adept in these technologies. Upskilling initiatives, therefore, are not temporary measures but an ongoing necessity in the automotive industry that is characterized by rapid technological advancements. The ability of the industry to adapt to these changes hinges on the successful upskilling of its workforce. When executed effectively, these upskilling initiatives will not only bridge the current skill gap but also will lay a foundation for a more innovative, sustainable, and economically robust automotive future.

Acknowledgements

No funding has been received for the development of the research

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

European Commission Fact Sheet "Sustainable and Smart Mobility Strategy", 9th December 2020.

Transport and the Green Deal (https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/transport-and-green-deal_en)

EV volumes (https://www.ev-volumes.com/)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

CEC-100. Uniform Provisions concerning the Approval of Vehicles with regard to specific requirements for the Electric Power Train.

Greek Legislation. (2021). Operation Terms of HV Electric Vehicles' Repair Shops. YA 194135 OGG 3407B.

Greek Legislation. (2020). Electric Vehicle Promotion. N 4710 OGG 142A.

Fire Safety Risks. Available at: [YouTube Link].

INFORMATION FOR FIRST AND SECOND RESPONDERSEMERGENCY RESPONSE GUIDE TESLA MODEL S ELECTRIC Version 001.

Allianz SE. (2022). Repair versus replace in motor insurance. Available at: [Allianz Link].

Pereirinha, P. G., Trovão, J. P., Santos, V. Electric Propulsion Vehicles Standardization: Where Are We? Available at: [Power-Sonic Blog].

Dorsz, A., Lewandowski, M. Analysis of Fire Hazards Associated with the Operation of Electric Vehicles in Enclosed Structures.

Neill, P. (2020). Electric Vehicle Fires — should we be concerned?

Fix Auto USA. (2019). Repairing Electric Cars: Things to Consider. Available at: [Fix Auto USA Blog].

Pertula, P., Saamanen, A., Vorne, J., Kangas, A., Santonen, T., Kannisto, E., Lantto, E., Lannetta, T., Rodriguez Llopis, I., Barrutabenia, L., Garcia, L., Valbuena, S. Li-Ion Battery's Life Cycle: safety risks and risk management at the workplaces.

D. Stimoniaris, D. Tsiamitros, T. Xenitopoulos, G. Tsiranidis, 2023,"Electromobility", ISBN: 978-618-86853-0-7.

Ramona Diana Leon (2023), Employees' reskilling and upskilling for industry 5.0: Selecting the best professional development programmes, Technology in Society 75 (102393)

Adrian Ciprian Firu, Alin Ion Tapîrdea, Anamaria Ioana Feier , George Draˇghici (2021), Virtual reality in the automotive field in industry 4.0, Materials Today: Proceedings 45, 4177-4182.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Upskilling and Reskilling on H2 technologies: The Green Skills for Hydrogen Project

Athanasia Ioannidou[a], Eleni Papista[a], Evridiki Mantela[a], Ioanna Mikrouli[a], Nikolaos Ntavos[a]

[a]Clean Technologies & Hydrogen Department, Cluster of Bioeconomy and Environment of Western Macedonia, Greece

Abstract

Hydrogen is a key element in decarbonizing the global energy systems as a versatile energy carrier. The rapidly growing attention of the European Hydrogen Value Chain is expected to generate new jobs over the coming years. Therefore, it is important to map the occupational profiles of workers in Declining Sectors and Transition Regions so as to provide them with upskilling and reskilling opportunities that will enable them to access new employment opportunities within the expanding Hydrogen sector. Green Skills for Hydrogen is a flagship project that will design and implement a Hydrogen Skills Strategy to meet the current and future skills needs of the Hydrogen value chain and provide the backbone of the renewable energy sector in Europe. Furthermore, the project will develop and test the Vocational Educational Programmes (VET) to address the skill needs of the hydrogen industry. In this paper, the current status of the urgent trainings in the region of Western Macedonia, Greece, was discussed and the impact of those trainings was presented.

Keywords: hydrogen, green skills, upskilling, reskilling, training programmes.

How to cite: Ioannidoua, A.; Papistaa, E.; Mantelaa, E.; Mikroulia, I.; Ntavosa, N. (2024) Upskilling and reskilling on h2 technologies: the green skills for hydrogen project. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 97-104. https://doi.org/10.4995/SEED2024.2024.19007

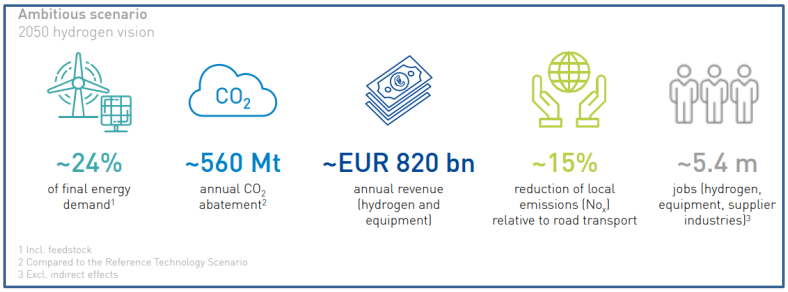
BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The global energy landscape is undergoing a remarkable shift as the world endeavours to combat climate change and enhance energy security by transitioning to cleaner, more sustainable energy sources. In this context, low-emission hydrogen has emerged as an important tool for decarbonising sectors in which emissions are hard to abate. The recent global energy crisis has also given more impetus to low-emission hydrogen as a means to bolster energy security. As a result, governments have strengthened their commitments to achieve net zero emissions, and low-emission hydrogen has become an integral part of their plans (International Energy Agency, 2023). In this framework, hydrogen plays a crucial role in the European Union's strategy to achieve its 2050 decarbonization goals, with an estimated 24% of hydrogen contributing to the total energy demand by that year. This ambitious goal is expected to result in an annual abatement of 560Mt of CO2, generate 820 billion euros in revenue, and achieve a 15% reduction in local emissions.

The European Union has given a powerful political signal to kick-start a clean hydrogen economy in Europe by 2030. The European climate strategy and the transition to a decarbonized economy will indeed imply a deep transformation of European energy production, storage, and consumption, with carbon-free power generation, increased energy efficiency, and the decarbonization of transport, buildings, and industry. This transition will require hydrogen production at a large scale, particularly clean hydrogen. In this context, a trained and skilled workforce is a prerequisite for achieving EU's objectives of scaling up local clean hydrogen production and establishing resilient hydrogen ecosystems. Across the EU, it has been estimated that green hydrogen can create up to 1 million direct, high-quality jobs by 2030 and up to 5.4 million such jobs by 2050. This works out to be approximately 10,300 jobs per €1 billion invested and includes jobs generated in the renewable electricity sector (Fuel Cells and Hydrogen 2 Joint Undertaking, 2019).

Fig. 1 - Benefits of hydrogen for the EU



Source: Fuel Cells and Hydrogen 2 Joint Undertaking (2019)

The current and future demand for skilled engineers and technical employees within the Hydrogen Value Chain cannot be met by existing training programmes, and Europe needs an innovative Hydrogen Skills Strategy that can accelerate the upskilling and reskilling of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

students and the workforce to address the increasing skills gap and ensure the European Renewable Energy sector can meet the challenging targets of the Green Transition (European Hydrogen Skills Strategy, Green Skills for Hydrogen project, 2023).

In this direction, the Green Skills for Hydrogen project aims to design and implement a highly innovative, effective, and sustainable Hydrogen Skills Strategy for Europe. This Strategy is designed to fulfill the skill needs of the rapidly evolving Hydrogen Value Chain in the short, medium, and long term. More specifically, the blueprint will provide the workforce with upskilling and reskilling opportunities, which will enable them to access new employment opportunities within the Hydrogen sector. To this end, the project aims to build a Hydrogen Skills Agenda to meet the ambitious European climate objectives and to seamlessly accompany the strategic roadmap for hydrogen set by the European Commission (Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of Regions, 2020).

Through the project, the development, testing, and rollout of the Vocational and Educational Training (VET) programmes will be conducted across Europe according to the latest market needs to empower workers and technical professionals. In the first phase, the urgent trainings were organized in Greece, Bulgaria, and the Netherlands, in order to establish a blueprint for the upcoming pilot trainings. These regions share the common characteristic that they are energy transition regions, moving away from fossil fuels towards more sustainable energy sources, such as hydrogen. Therefore, it is of great importance to develop hydrogen trainings in these regions, to facilitate this transition.This paper aims to present the urgent trainings that have already been organized in the region of Western Macedonia, Greece during the implementation of the Green Skills for Hydrogen project.

2. Urgent trainings in the region of Western Macedonia

The upskilling and reskilling training programmes in the hydrogen sector are rooted in the global transition towards sustainable energy solutions. With the increasing recognition of hydrogen's potential as a clean and versatile energy carrier, there is a growing demand for skilled professionals in this field. Reskilling and upskilling training programmes are educational initiatives designed to enhance or teach new skills and knowledge to the workforce and young people in order to bridge the skills gap and ensure that the workforce is proficient in implementing hydrogen technologies. Therefore, the development of new modules and curricula is corresponding to educate the workforce already involved in this ecosystem, and to train young people to work in this increasingly expanding sector.

The Region of Western Macedonia (RWM) has produced over 75% of the energy used in Greece since 1955 through coal-fired power plants, making it the country's main energy hub, and contributing significantly to electricity supply with the exploitation of lignite deposits for power generation (Ziouzios et al., 2021). Lignite, though, has been banned from EU energy

 BY-NC-SA

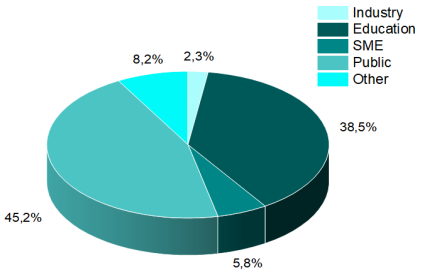
source policies to achieve CO_2 emissions reduction. Climate change, the energy crisis, and the national decarbonisation plan unveiled by the Greek government, compel the Region to embrace new development patterns. The OECD (Organisation for Economic Cooperation and Development), in its Regional Outlook 2021 report on Greece - Progress in the net zero transition, highlights the RWM as generating 5 times higher GHG emissions (>50 tCO_2e) than the OECD average of 11.5 tCO_2e (OECD, 2021). In this context, it becomes evident that there is an urgent need to transition to CO_2-free technologies and a related necessity for operational knowledge on these technologies by the existing and future workforce.

The urgent trainings are educational programmes designed to rapidly provide knowledge and skills to individuals, professionals, or the workforce in a specific region. In Greece, three urgent trainings were organised, designated for these occupational profiles, which are affected by the Energy Transition in Western Macedonia. The trainings aimed at providing opportunities to undergraduate and postgraduate students, engineers, and technicians, to pursue a career in the hydrogen value chain. In this framework, the training programmes were organised by the Cluster of Bioeconomy and Environment of Western Macedonia (CluBE) and Advent Technologies, in cooperation with the University of Western Macedonia.

2.1 Target groups

Considering the project's objectives, the target groups of the urgent trainings consisted of undergraduate and postgraduate students as well as engineers and technicians. More specifically, the Masterclass: "One-Day Hydrogen" was suitable for stakeholders, policymakers, engineers, innovators, researchers, and energy producers. During the trainings, participants lists were distributed, in order to monitor the specific target groups and the participants' backgrounds (Fig. 2 – Fig. 4).

Fig. 2 - Participants of the Masterclass: "One-Day Hydrogen" training

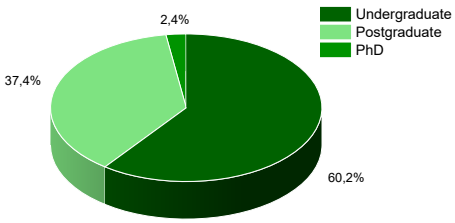


Source: Figure 2 was created from information derived from the participants lists that were distributed during the Masterclass: "One-Day Hydrogen" training (2023)

The Masterclass: "One – Day Hydrogen" paved the way for more specialised urgent trainings. In this context, the "Hydrogen Summer ScH2ool" event was organised shortly afterwards, which was designed for undergraduate and postgraduate students interested in hydrogen technologies.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

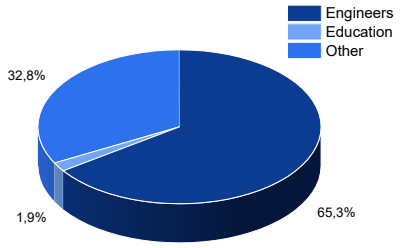
Fig. 3 - Participants of the "Hydrogen Summer ScH2ool" training



Source: Figure 3 was created from information derived from participants lists that were distributed during the "Hydrogen Summer ScH2ool" training (2023)

Finally, the "Engineering our Future: Developing Hydrogen Skills" training was implemented for the engineers of the Technical Chamber of Greece/Department of Western Macedonia (such as chemical, mechanical, civil, and electrical engineers). The total number of participants in the three trainings in Western Macedonia was more than 100, which was the declared KPI in the proposal.

Fig. 4 - Participants of the "Engineering our Future: Developing Hydrogen Skills" training



Source: Figure 4 was created from information derived from participants lists that were distributed during the "Engineering our Future: Developing Hydrogen Skills" training (2023)

2.2 Topics

The Masterclass: "One-Day Hydrogen" training covered the entire hydrogen value chain, the role of hydrogen in the energy transition, in the region of Western Macedonia, and the creation of a Pan-European Hydrogen Industry Hub of Western Macedonia, aligning with the ultimate aim to achieve a carbon-neutral economy by 2050. The participants had the chance to explore hydrogen production, transport, storage, and end-uses. They were also able to learn more about the technological, economic, regulatory, and safety context of hydrogen, as a critical player in the global energy transition.

The "Hydrogen Summer School" programme covered hydrogen technologies, electrolyzers and fuel cells, hydrogen safety issues, H2-to-X technologies, Hydrogen Refueling Stations, as well as funding opportunities for hydrogen. During the training, a workshop on creating a hydrogen start-up company took place, as well as a round table regarding the creation of a

2024, Editorial Universitat Politècnica de València BY-NC-SA

Hydrogen Valley in Western Macedonia. In addition, two study visits were held, at the Laboratory of Alternative Fuels and Environmental Catalysis (LAFEC) at the University of Western Macedonia in Kozani and at the Centre of Research and Technologies (CERTH)/Chemical Process & Energy Resources Institute (CPERI) in Thessaloniki.

The last urgent training, entitled: "Engineering our Future: Developing Hydrogen Skills" was organised in cooperation with the Technical Chamber of Greece/ Department of Western Macedonia and designed to address Just Transition in Western Macedonia. The topics of the training included the current status and challenges of hydrogen technologies, uses, properties, and safety issues regarding hydrogen utilisation for heat and power. Furthermore, Advent Technologies' fuel cell systems were presented during the training, with a focus on how the innovative HT-PEM fuel cell technology effectively replaces polluting diesel generators, providing clean power to diverse sectors such as marine, automotive, and aviation.

2.3 Speakers

The speakers of the urgent trainings in Greece were approximately fifty in total and included professors from Greek universities (University of Western Macedonia, Aristotle University of Thessaloniki, National Technical University of Athens), as well as European academic institutions (KIT - Karlsruhe Institute of Technology, University of Genoa). Furthermore, among the speakers were representatives of industrial companies related to the hydrogen and fuel cell technologies sector (Advent Technologies, Hellenic Hydrogen, Motor Oil, DESFA, DEPA, Helbio), research institutions (CERTH/CPERI, FORTH/IG), start-up hydrogen companies (B-Hydrogen) and European associations (Hydrogen Europe, Clean Hydrogen Partnership/Joint Undertaking).

Fig. 5 - Urgent Trainings in Western Macedonia, Greece



Source: Figure 5 was created from photographs taken during the urgent trainings in Western Macedonia (2023)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.4 Recommendations for implementing trainings on hydrogen

The urgent trainings highlighted the need for recommendations to enhance future trainings. Policymakers should invest in hydrogen technology training by collaborating with educational institutions and industry partners, supporting apprenticeships, internships, and on-the-job training. Educators should offer hands-on learning, align curriculum with industry standards, and promote lifelong learning. Industry stakeholders should prioritize employee training, collaborate with educational institutions, promote career pathways, and share success stories in the hydrogen sector workforce training.

3. Future perspectives

It is worth highlighting that the implementation of the urgent trainings will serve as the initial step for the organisation of the pilot training programmes in 9 European countries, which will target more specialised aspects of the hydrogen sector. By expanding the scale of the urgent trainings and organizing them on international level, a larger and more specific target group can be provided with the necessary knowledge and skills essential for effective involvement in hydrogen technologies. The increased reach ensures that professionals from various sectors have access to training, fostering a more inclusive workforce development strategy. As these scaled-up trainings cover a broader audience, they create a basis for the upcoming pilot trainings, setting the stage for specialized education tailored to specific roles within the hydrogen industry. In general, future research on hydrogen trainings could focus on tailoring the trainings programmes in order to be more interactive and practical, such as establishing hands-on training activities, organizing study visits in hydrogen-related infrastructures with the aim of bridging the gap between theory and practice. By addressing these research directions, we can strengthen the capacity of individuals and organizations to participate in and contribute to the growing hydrogen sector, ultimately accelerating the transition to a sustainable and low-carbon energy future.

4. Conclusion

In conclusion, with the global transition towards sustainable energy systems driving the European policy agenda, fuel cells, and hydrogen have emerged as a key solution for decarbonizing various sectors, including transportation, industry, and power generation. As the demand for this sector grows rapidly, it is crucial to assess the skills requirements and develop effective education and training programmes to equip the workforce with the expertise needed to support the widespread adoption and integration of FCH technologies in the economy. The Green Skills for Hydrogen project not only addresses the skills requirements across the entire hydrogen value chain, encompassing production, distribution, transport, and storage but also emphasizes on the necessity of a forward-looking Hydrogen Skills Strategy for Europe. By targeting workers in Declining Sectors and Transition Regions,

2024, Editorial Universitat Politècnica de València BY-NC-SA

the project aims to provide upskilling and reskilling opportunities, ensuring the seamless transition into the hydrogen sector.

Acknowledgements

This research has been financed by the European Union under the call ERASMUS-EDU-2021-PI-ALL-INNO and the project Green Skills for Hydrogen (Grant Agreement number: 101056448).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of Regions, (2020). A hydrogen strategy for a climate-neutral Europe, COM (2020) 301. https://www.eu2018.at/calendar-events/political-events/BMNT-

Green Skills for Hydrogen project, (2023). European Hydrogen Skills Strategy, https://greenskillsforhydrogen.eu/wp-content/uploads/2023/11/D2.2-Skills-Strategy-02-11-2023.pdf

Fuel Cells and Hydrogen 2 Joint Undertaking, (2019). Hydrogen Roadmap Europe: A sustainable pathway for the European Energy Transition. https://doi.org/10.2843/249013

International Energy Agency, I., (2023). Global Hydrogen Review 2023. www.iea.org

OECD, (2021). Regional Outlook 2021 - Country notes Greece - Progress in the net zero transition

Ziouzios, D., Karlopoulos, E., Fragkos, P., & Vrontisi, Z., (2021). Challenges and opportunities of coal phase-out in western Macedonia,Climate, 9(7). https://doi.org/10.3390/cli9070115

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Energy-Campus Feuchtwangen: Sustainable energy education for supporting decarbonization in semi urban areas

Haresh1 Vaidya[a], Kanav2 Bhalla[a]

[a]Energy-Campus Feuchtwangen, University of Applied Sciences Ansbach, Germany

Abstract

Energy-Campus Feuchtwangen has been established to serve as a pivotal hub for sustainable energy education, strategically positioned to support decarbonization initiatives in semi-urban area of Middle Franconia. This study aims to assist policymakers, universities, regional development entities, local authorities, and vocational training institutes in encouraging investment in sustainable energy education in semi-urban areas. As part of the broader regionalization approach of the University of Applied Sciences Ansbach, mini campuses like Energy-Campus Feuchtwangen were strategically established in semi-urban areas to offer effective curricula, taking into consideration local requirements. Our experience has shown that the establishment of mini campuses dedicated to sustainable education facilitates regional development in semi-urban areas. By aligning technical and academic approaches with the specific needs of the semi-urban landscape, Energy-Campus Feuchtwangen serves as a knowledge transfer centre for supporting decarbonization not only regionally, but also globally. The emphasis on sustainable education at these mini campuses extends beyond regional boundaries, positioning Energy-Campus Feuchtwangen as a competent partner in sustainable energy education and decarbonization efforts.

Keywords: Decarbonization; Mini-Campus; Regionalization; Semi-urban; Living-lab.

How to cite: Vaidya, H. and Bhalla, K. (2024) Energy-Campus Feuchtwangen: Sustainable energy education for supporting decarbonization in semi urban areas. In proceedings: Conference on Sustainable Energy Education – SEED 2024, Valencia, Spain, 3 - 5 July 2024, pp. 105-111. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The German government places a high priority on decarbonizing the energy sector, evident in its Action Plan 2030[1]. The ambitious goal of achieving CO_2 neutrality by 2050 necessitates the involvement of outreach programs and experts in implementing sustainable and renewable energy measures. Playing a crucial role in this endeavor is the Energy-Campus Feuchtwangen, an integral part of the University of Applied Sciences Ansbach's regionalization strategy. Positioned as a technology transfer center, it strives to contribute significantly to achieving these decarbonization objectives.

Mini campuses, exemplified by Energy-Campus Feuchtwangen, emerge as regional innovation drivers, actively engaging in higher education and research and development projects. Kaiser (2021) proposed that such mini campuses function as 'growth poles,' thereby connecting various entities and enriching the regional innovation landscape. Going beyond traditional education the Energy-Campus Feuchtwangen acts as a living-lab for energy research- a clear demonstration of its commitment to innovation and sustainability.

Living-labs, in line with the innovation model proposed by Kaiser (2021) actively promote public involvement and foster a collaborative approach to regional development. By converging academia, governance, and industry, Energy-Campus Feuchtwangen becomes a hub where theoretical knowledge meets real-world energy applications, driving the decarbonization agenda.

The holistic institutional approach adopted here draws inspiration from the World Action Program for Education for Sustainable Development[2], the National Action Plan for ESD [3], the German Rectors' Conference (HRK)[4] as well as the findings of HOCH-N project as brief recommendation to action by Hemmer (2021). These recommend that the higher educational institutes align their core processes with Sustainable Development Goals (SDGs)[5]. Research activities are designed to incorporate sustainability principles, emphasizing societal responsibility. Sustainability and ESD are systematically integrated into all academic programs, fostering student-centered, competence-oriented learning. Energy-Campus Feuchtwangen actively engages in sustainability transfer by closely collaborating with local stakeholders. Student involvement is instrumental, with students acting as multiplicators for sustainability initiatives. This is achieved through by combining teaching, research, transfer, and student engagement for a more profound societal impact.

[1] https://www.bundesregierung.de/breg-en/issues/climate-action#:~:text=The%20Federal%20Government%20will%20make,push%20climate%2Dfriendly%20mobility%20forward

[2] https://www.bne-portal.de/bne/en/global-action-programme/global-action-programme-on-esd-in-germany.html

[3] https://www.bne-portal.de/bne/shareddocs/downloads/files/bmbf_nap_bne_en_screen_2.pdf?__blob=publicationFile&v=5

[4] https://www.hrk.de/positionen/beschluss/detail/fuer-eine-kultur-der-nachhaltigkeit/

[5] https://sdgs.un.org/goals

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The comprehensive review provided about the global status quo regarding renewable energy education by Kandpal & Broman (2014) reveals challenges such as the absence of structured curricula, a shortage of qualified instructors, limited funds for facilities, and uncertainty about employment prospects. To address these challenges, it is crucial to integrate renewable energy concepts across educational levels, standardize curricula globally, provide a balance of academic and practical training, develop teaching materials, and raise awareness about energy efficiency. Short-term courses for policymakers, collaborative networks, and assessments of future societal needs are essential. Establishing guidelines, standards, and regulations ensures the quality and accreditation of programs. Continuous improvement and adaptability to technological advancements and policy changes are vital for success. The inputs from various sources mentioned above have played a vital role in designing the approach for providing sustainable energy education at Energy-Campus Feuchtwangen. This shall be elaborated in the next section.

2. Approach

Fig 1.- Energy-Campus Feuchtwangen



Source: Energy-Campus Feuchtwangen

2.1 Energy-Campus Feuchtwangen as a living-lab for hands-on Smart Energy Research

Energy-Campus Feuchtwangen serves as a living-lab for experimental research on decarbonization. Through immersive hands-on projects in the field of heating, cooling, ventilation, and sector coupling, specially designed to cater to renewable energy applications, students and researchers engage in innovative solutions for decarbonization. This living-lab goes beyond conventional classrooms, seamlessly integrating theoretical knowledge into real-world applications, thereby advancing sustainable energy solutions.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The innovative and climate-friendly research laboratory at Energy-Campus Feuchtwangen exemplifies a model project within the "Energy Efficiency Houses Plus-Educational Buildings" nationwide funding program by The Federal Office for Building and Regional Planning (BBSR)[6]. This program enabled the upgrade of existing structures to energy-efficient houses, leading to substantial energy savings. The positive overall energy balance of the campus building, driven by a surplus in electricity generation from a photovoltaic system, underscores the commitment to sustainable practices. The Energy-Campus Feuchtwangen showcases cutting-edge technology and sustainable energy supply, including an innovative ice storage tank for sustainable seasonal heat storage. This has already served as a model for other projects in the region.

Fig 2.- Ice storage



Fig 3.- Smart Heating and Cooling



Source: Energy-Campus Feuchtwangen

2.2 Sustainable energy-based curriculum

The curriculum at Energy-Campus Feuchtwangen reflects a forward-thinking approach with a focus on Smart Energy Systems and Sustainable Building Systems integrated into master's programs. The master's program for Energy Systems involves advanced training for engineers, emphasizing the design, construction, and operation of sophisticated and sustainable energy systems. Specialization includes decentralized and renewable energies such as combined heat and power, solar energy, biomass, and geothermal sources. The curriculum spans multiple semesters, encompassing lectures, exercises, laboratories, seminars, and research projects.

A distinctive feature of the program is the incorporation of research-intensive thesis projects, allowing students to actively contribute to the field. The program's flexibility accommodates preferences for technical, economic, or organizational aspects. A mandatory practical

[6] https://www.bbsr.bund.de/BBSR/DE/forschung/programme/zb/Auftragsforschung/5EnergieKlimaBauen/2015/ehp-begleitforschung/bericht-teil-2.pdf?__blob=publicationFile&v=2

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

component, in the form of internships or research projects, provides valuable hands-on experience and facilitates industry networking.

The curriculum is meticulously designed to empower graduates for roles as engineers and energy consultants. Emphasizing energy-efficient buildings as integral components in enhancing flexibility in the energy sector, graduates gain expertise in energy-efficient construction methods, sustainable building operations, and the increased use of renewables for heating, cooling, and electricity to achieve EU targets for the building sector [Renewable Energy Directive, adopted in 2023][7]. Integration of digitization in construction processes through Building Information Modelling (BIM) tools enhances graduates' capabilities for collaborative work in the construction process.

The courses also include sector coupling, emphasizing the interplay between electricity generation, heating, and cooling. Courses cover building automation, control, and economic engineering to provide a holistic understanding. Certification requirements specified by the government are seamlessly integrated into different courses, ensuring graduates' eligibility for government-approved certification.

In addition to the standard curriculum, Energy-Campus Feuchtwangen also offered two ESF-funded[8] professional training courses – "Energieberater 2.0" and "Energy System Expert" – focusing on digital and ecologically sustainable competencies. These courses catered to employees, particularly from small and medium-sized enterprises, imparting skills aligned with the Building Energy Act (GEG) and addressing the evolving energy landscape. In the future, these courses shall be offered commercially to increase the outreach of this important topic.

2.2 Collaboration with Local Stakeholders

Energy-Campus Feuchtwangen plays a proactive role in collaborating with government stakeholders to address communal energy supply issues. The Feuchtwangen municipal utilities aim to achieve a carbon-neutral supply of electricity, heat, and mobility by 2035. In collaboration with Siemens AG, the Energy-Campus Feuchtwangen conducted a decarbonization study, guiding the implementation of planned measures. The initiative integrates renewable energy, energy efficiency, and low-carbon mobility solutions for a sustainable energy transition. Tracking progress in the coming years will be crucial for assessing the technical advancements and impact.

[7] https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

[8] https://www.esf.bayern.de/esf-foerderung/foerderaktion/fp2021-2027/betrieblicheweiterbildung.php

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.3 Knowledge Exchange Projects

Interregional outreach projects extend the impact of Energy-Campus Feuchtwangen beyond its immediate surroundings. Collaborations with national and regional organizations such as the GIH e.V.[9] involve training sessions and workshops. This symbiotic relationship facilitates knowledge exchange, positioning Energy-Campus Feuchtwangen as a leader in sustainable energy education and contributing to a nationwide movement toward decarbonization.

3. Results

The operational strategy employed by Energy-Campus Feuchtwangen has been pivotal in providing accessible and applied sustainable knowledge for diverse local stakeholders. Its strong regional presence has effectively mitigated common challenges faced by small-scale communities in energy education. The tailored and pragmatic approach towards local industries and communities has resulted in a streamlined response mechanism, reducing turnaround time for inquiries, and optimizing resource allocation. Given the predominantly regional focus of cooperation projects, the visibility of Feuchtwangen has markedly increased, drawing interest from neighbouring organizations seeking collaboration. Graduates, equipped with expertise in both regional and global energy domains, secure employment opportunities in local consultancy firms and international organizations.

The creation of Energy-Campus Feuchtwangen highlights the transformative power of investing in higher education within semi-urban areas, playing a crucial role in the ongoing decarbonization efforts while fostering economic growth with implications that reach far beyond regional boundaries. Moreover, the campus concept has facilitated the establishment of trust among the local population, as they are introduced to new technologies and benefit from knowledge exchange facilitated by highly qualified professors and Ph.D. holders. These experts actively engage in dialogue with the surrounding community, offering optimal solutions to encountered challenges. This inclusive process extends to students who undertake theses at the campus, enabling them to gain grassroots-level insights, resulting in a mutually beneficial outcome for the campus, students, and local residents.

4. Challenges and Outlook

Establishing mini campuses in semi-urban areas presents distinct challenges impacting their operations and growth. Attracting and retaining skilled educators becomes problematic, potentially leading to gaps in academic expertise. Insufficient funding and a smaller student pool hinder the development of cutting-edge research programs. Despite these challenges,

[9] https://www.gih.de/

2024, Editorial Universitat Politècnica de València BY-NC-SA

mini campuses can showcase their activities and achievements to extend outreach. Moreover, if the university and local authorities invest in this concept, replication becomes easier. This approach not only aids neighbouring areas in technological advancement but also entails efficient infrastructure and administrative planning due to the compact campus size, resulting in decreased project planning time and paperwork, expediting the launch process. Thus, with strategic investment and collaboration, mini campuses can thrive and contribute significantly to their communities which makes this model easily replicable in less time compared to setting up a university.

Acknowledgements

We would like to thank Mr. Patrick Ruh, 1. Mayor of the city of Feuchtwangen, Mr. Herbert Lindörfer, 3. Mayor of the city of Feuchtwangen and the Bavarian Ministry of Science and Technology for their financial support in setting up Energy-Campus Feuchtwangen.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper

References

Kaiser, N. (2021). Technology amongst the Fields: Mini Campuses as endogeneous Growth Poles in lower Density Regions - a Case Study from the Nuremberg Metropolitan Region. *Florida Journal of Development*, 3(4), 5695-5705. https://doi.org/10.46932/sfjdv3n4-129

Kandpal, T., & Broman, L. (2014). Renewable Energy Education: A Global Status Review. *Renewable and Sustainable Energy Reviews*, 34, 300–324. https://doi.org/10.1016/j.rser.2014.02.039

Hemmer, I. (2021). Nachhaltige Entwicklung von und mit Hochschulen: Handlungsempfehlungen. Deutsche Gesellschaft für Nachhaltigkeit an Hochschulen e.V. - DG Hoch-N.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Solar energy and efficiency at IES El Cabanyal

Ramón Soria Momparler[a] and David Sornosa Cervera[b]

[a] Departamento de Electrónica, IES El Cabanyal, España
[b] Departamento de Electrónica, IES El Cabanyal, España

Abstract

When we think of colleges, what comes to mind is: classrooms, workshops, teachers, students, etc... Nowadays there are other factors that add value to colleges.

Our colleges must not only be academies of knowledge, it is important that their impact on society and the planet is positive in other important aspects. We have to consider that many of these colleges are like small towns, in terms of number of people and that we spend much of our time there. We live in a world in which factors such as sustainability are vital for our environment, in order to achieve a better society and world.

Within these sustainable factors we find renewable energies and energy efficiency. Reducing energy consumption by trying to maintain comfort standards and reducing CO_2 emissions and other greenhouse gases is crucial to achieving sustainable environment standards and reducing CO_2 emissions and other greenhouse gases is crucial to achieving sustainable environments.

Keywords: Sustainability; Renewable energy; Solar panels; Aerothermal.

How to cite: Soria Momparler, R. and Sornosa Cervera, D. (2024) Solar energy and efficiency at IES El Cabanyal. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 112-119. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The IES El Cabanyal is a Vocational Training Center located in Valencia, Spain, and has about 1,500 students, 160 teachers, cleaning staff and administrative services staff. Of the total student body, around 900 are from Vocational Training Degrees from different professional families; Electricity and Electronics, Installation and Maintenance, Personal Image and Transportation and Vehicle Maintenance.

The IES El Cabanyal, both from the management team and from the teaching staff, has always shown a high interest in sustainability as a pillar of the educational system. Renewable energies, energy savings through energy efficiency are aspects that accompany our daily lives.

Since its new construction, the IES El Cabanyal had a small Photovoltaic installation and another Solar Thermal installation, the latter for the production of ACS (Domestic Hot Water) that serves the workshops of the professional degree "Personal Image" and to the changing rooms of "Installation and maintenance" and "Transportation and maintenance of vehicles" degrees.

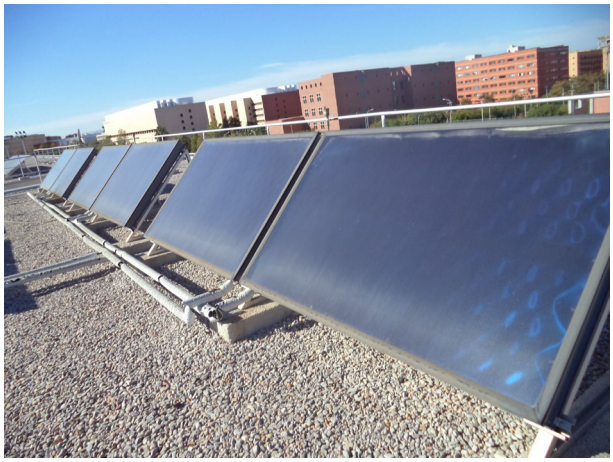
Fig. 1 – Initial photovoltaic installation



Source: IES El Cabanyal (2008)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 – Solar Thermal Installation



Source: IES El Cabanyal (2008)

This small photovoltaic solar energy installation is only 3.3 KW, as a practical provision, so it is not of much use to meet the colleges' electricity consumption demands.

In subsequent years, continuing with the mentality of energy saving and awareness of the use of renewables, the expansion of the photovoltaic solar installation was proposed in order to be energy self-sufficient and have surpluses that in the future become a solidarity project that will allow the donation of energy.

The last phase of construction of our facilities, which corresponds to the building of the cafeteria, sports centre, changing rooms, parking lots and sports areas, coincides with a moment of environmental awareness that forces institutions, both for compliance with regulations and for the desire to save energy, to use renewable energies for domestic hot water (DHW) production and for air conditioning. In this case, an aerothermal installation and heat recovery equipment have been chosen. This technology, in addition to having a lower carbon footprint than conventional systems, allows achieving COP and EER performance (COP Coefficient of Performance as the ratio between the heating power and the useful absorbed power of the equipment, and the EER Energy Efficiency Ratio as the ratio between the total cooling power and the power absorbed by the equipment) higher than any other commercial technology on the market.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 3 – Aerothermal and heat recovery equipment.



Source: IES El Cabanyal (2008)

Continuing with the idiosyncrasy of our college, energy efficiency and achieving comfort with lower consumption and impact are also important. From the Department of the professional family "Installation and Maintenance" of the college, different collaboration projects have been carried out with companies in the air conditioning sector to be able to train students both in new technologies and in compliance with state and community regulatory requirements.

Thanks to our collaboration with ATECYR, our teachers and students of "Installation and Maintenance" will have the opportunity of collaborate or take part in activities or seminars in this sector, in order to foster the collaboration between our parties, as well as receive a collection of publications for our library, so our students will be able to look up for the latest news in the sector.

Our agreement with DAIKIN has allowed us to acquire Aerothermal equipment for the training of our students. This type of technology will become the short-term solution to the energy needs of single-family homes, replacing gas boilers or heaters. Therefore, this agreement will allow students to be trained in new energy trends that undoubtedly involve Aerothermal Energy and integrated systems that allow managing the use of energy in both the ventilation and air conditioning areas.

It is also remarkable that we have formalized a collaboration agreement with AIRZONE, a leading company in intelligent air conditioning for the training of our students in the integration of all the energy systems that coexist in buildings.

2. Implementation of the photovoltaic solar installation

2.1. Environmental impact

When building a facility that generates electrical energy, the environmental impact is a factor to consider when we talk about sustainable systems. Photovoltaic modules have a relatively

BY-NC-SA 2024, Editorial Universitat Politècnica de València

low environmental impact compared to other forms of energy generation. These modules do not emit greenhouse gases or other atmospheric pollutants. However, it should be noted that their manufacturing requires a significant amount of energy. Furthermore, the production and dismantling of solar panels at the end of their useful life can generate a negative impact on the environment in terms of greenhouse gas emissions, consumption of natural resources and the production of toxic waste.

Regarding solar inverters, their environmental impact is mainly due to the materials used in their production and the energy consumed in their manufacturing. The main environmental benefit of these devices is their ability to produce energy from sunlight, reducing dependence on fossil fuels and reducing greenhouse gases. So, as part of a solar energy system, they typically have a useful life of between 10 and 15 years. Although their lifespan is shorter than the lifespan of solar panels (25-30 years), inverters contribute to the long-term sustainability of solar energy systems.

Regarding the use of materials and waste, solar inverters contain electronic components and metals, some of which require high energy consumption processes for their extraction and refining. When a solar inverter reaches the end of its useful life, it can contribute to e-waste if not properly recycled. Many manufacturers are working towards more sustainable production methods, including better recycling programs and the use of less harmful materials.

2.2. Quality criteria

Initial cost, evaluating the purchase prices of the inverter and panels along with the installation costs is an important factor to ensure the adjustment to the available budget.

Additionally, considering conversion efficiency is important to maximize your return on investment when converting solar energy to electricity efficiently.

Reviewing the useful life and warranty of the elements is a primary factor to ensure the long-term investment.

Selecting the appropriate type of solar panel, such as monocrystalline, polycrystalline or amorphous silicon, depending on the location and needs of the installation.

Monitoring Capability: Assess whether the inverter offers real-time monitoring capabilities for effective tracking of system performance.

Durability and resistance to environmental conditions: ensure that the panels are resistant to extreme weather conditions, such as rain, snow, wind and hail.

2024, Editorial Universitat Politècnica de València BY-NC-SA

2.3. Interoperability of the installation with the electrical system

As we mentioned previously, another of the installation's objectives is solidarity. Surplus energy can be used for social purposes. The system will not store surpluses, but rather they will be exported to the electrical grid.

The installation monitoring system will allow you to view the instantaneous, daily, monthly and annual energy production through an application in which you can view and analyse the following variables:

- Photovoltaic power produced, self-consumption and exceeded to the grid.

- Power taken from the network.

In addition, the application will alert users through notifications to report any problems or anomalies in their solar panel, thus allowing them to find a quick solution to monitor the performance of the device. It is also intended to produce weekly and monthly reports on the history of energy production, which will serve to analyse the performance of the solar panels over time.

2.4. Business intervention in the process

The implementation of the system requires several phases that will affect different types of companies.

Project: design and engineering of the photovoltaic system, including the selection of solar panels, inverters, efficiency calculations, and permit procedures. Billing will depend on the complexity of the project and the agreed rate for your services. Additionally, it is necessary to ensure that the installation complies with building codes and local requirements.

Equipment: solar panels and inverters for which billing will depend on the quantity and type of equipment required. Special mounting structures are also needed for solar panels.

Execution of the work: a photovoltaic system installation company will carry out the physical installation of the panels, inverters, wiring, and mounting systems. An electrician will make the electrical connections and ensure that the system is safely connected to the mains.

Maintenance and continuous supervision: a technician in charge of maintenance and service is required to perform periodic maintenance services and monitoring of the system.

Inspections and certifications: A certification services technician is required to ensure that the installation complies with local standards and regulations.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Descriptive data of the Facility

Technology: Solar photovoltaic

Installation mode: Self-consumption connected to the grid without surplus.

Rated power (kW): 100

No. of modules 192

Necessary surface area (on horizontal roof): 479.09 m²

Energy produced: 150,762.77 kWh/year

Self-consumed energy: 108,231.48 kWh/year

Percentage of self-consumed energy: 71.78%

Fig. 4 – *Current photovoltaic installation*



Source: IES El Cabanyal (2023)

4. Energy saving data

Currently, IES EL Cabanyal is achieving a degree of savings on the electricity bill of 60%. This amount of energy saved on the consumption of the supply company is due to the installation of solar panels.

The figure will increase to 90% savings when the supply company authorizes compensation. At that moment the excess unconsumed energy will be poured into the electrical grid. This surplus will produce an economic return on the electricity bill.

Acknowledgements

No funding has been received for the development of the research.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Ni, Long; Dong, Jiankai; Yao, Yang; Shen, Chao; Qv, Dehu; Zhang, Xuedan. A review of heat pump systems for heating and cooling of buildings in China in the last decade. Renewable Energy 84. 2015.

Modular Home. Aerothermal vs Heat Pump. April, 2024. https://modularhome.es/en/blog/aerothermal-vs-heat-pump

Ketier. What is aerothermal energy and what are its advantages and disadvantages? https://www.ketier.com/en/blog/what-is-aerothermal-energy-and-what-are-its-advantages-and-disadvantages/

Iberdrola. Aerothermal energy, a sustainable and efficient option. https://www.iberdrola.com/sustainability/what-is-air-source-heat-pumps

Stoppato, A. Life cycle assessment of photovoltaic electricity generation. Energy,

Volume 33, Issue 2. 2008.

https://www.sciencedirect.com/science/article/abs/pii/S0360544207002137?via%3Dihub

Heath, Garvin, Dwarakanath Ravikumar, Silvana Ovaitt, Leroy Walston, Taylor Curtis, Dev Millstein, Heather Mirletz, Heidi Hartmann, and James McCall. Environmental and Circular Economy Implications of Solar Energy in a Decarbonized U.S. Grid. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-80818. 2022.

https://www.nrel.gov/docs/fy22osti/80818.pdf

Bošnjakovi´c, M.; Santa, R.; Crnac, Z.; Bošnjakovi´c, T. Environmental Impact of PV Power Systems. Sustainability 2023, 15, 11888. 2023.

https://doi.org/10.3390/su151511888

IRENA and IEA-PVPS. "End-of-Life Management: Solar Photovoltaic Panels," International Renewable Energy Agency and International Energy Agency Photovoltaic Power Systems. 2016.

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf

Kuby Renewable Energy Ltd. The Positive and Negative Environmental Impacts of Solar Panels. https://kubyenergy.ca/blog/the-positive-and-negative-environmental-impacts-of-solar-panels

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Towards a more sustainable university campus: the case of ETSII LivingLab at Universitat Politècnica de València (Spain)

Carla Montagud Montalvá, Javier Sanchis Saez, Javier Soriano Olivares, César Pagani Quiroga, Guillermo Escrivá Escrivá and Raúl Simarro Fernández
School of Industrial Engineering, Universitat Politecnica de Valencia, Spain

Abstract

Interactive and cooperative learning are essential in engineering studies to prepare students for real-world problems. Living labs are an excellent resource for this type of teaching and learning process. University campuses with living labs provide practical settings where students can apply their academic knowledge in real-life situations, promoting cooperation and group problem-solving. The ETSII LivingLab was created by the school of Industrial Engineering (ETSII) at the Universitat Politècnica de València to raise awareness and develop innovative solutions that contribute to achieving the Sustainable Development Goals (SDGs). It serves as a test lab for new technologies for decarbonization and sustainability improvement, and a platform for collaborative ideation and social activation. To achieve this, we formed a diverse team consisting of professors, students, university staff, chairs, and representatives from public and private companies to ensure all stakeholders were represented. We developed a data monitoring and acquisition system to measure and monitor the main dimensions of sustainability in institutional buildings using key performance indicators. The ETSII LivingLab project engaged the entire school community and provided an accessible platform for teaching and research activities to improve the sustainability of the building. This paper outlines the project's key features and activities, which can be replicated in similar institutional buildings on campus or in the city.

Keywords: living lab, sustainability; decarbonisation strategies; knowledge co-creation; cooperative interactive learning.

How to cite: Montagud Montalvá. C.; Sanchis Saez, J.; Soriano Olivares,J.;Pagani Quiroga,C.; Escrivá Escrivá, G. and Simarro Fernández, R. (2024) Towards a more sustainable university campus: the case of ETSII LivingLab at Universitat Politècnica de València (Spain). In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 120-127. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Climate emergency calls for immediate response. EU Missions (European Commission, 2022) are portrayed as particular goals aimed at reducing the consequences of climate change. Particularly, The European Commission has recently named Valencia as one of the 100 European towns embracing the challenge of becoming carbon neutral by 2030. As one of Spain's leading technological universities, the UPV is well-positioned to support the València 2030 Climate Mission. The university can leverage its reputation to educate students about climate change, prepare local businesses and public administrations for the transition, and drive the development of new knowledge and technologies. In this context, the UPV Living Lab initiative (Vice-Rectorate for Sustainable Development of Campus, 2022) was launched by Universitat Politècnica de València (UPV).

A living lab is a physical or virtual space in which to solve societal challenges, especially for urban areas, by bringing together various stakeholders for collaboration and collective ideation (Hossain et al,2019). The UPV Living Lab initiative arises as a place for experimentation and creativity in search of long-term solutions to hasten the Universitat Politècnica de València's and the city's journey towards carbon neutrality. The project was inspired by similar initiatives implemented by other Spanish universities, including the Technical University of Madrid (UPM), which established a Living Laboratory of Sustainability to test and experiment with sustainable technologies and serve as a meeting place for UPM members (Mataix-Aldeanueva et al., 2017).

It is essential to raise public understanding of the value of sustainability and environmental protection in order to address the climate emergency. People change their behavior as a result of this social awareness, taking up more ecologically friendly habits. This was observed by Gomes et al. (2017), who developed a pilot project in Lisbon where ICT equipment was installed in different buildings on campus with two main objectives: firstly, to identify the most effective practices for energy savings; and secondly, to calculate and identify the savings resulting from user behaviour transformation. The overall savings obtained were almost 40%. The utilisation of a Living Lab as a teaching tool becomes an effective approach in this situation. Participation in projects addressing the climate crisis enables students to gain a deeper understanding of environmental issues and contribute to innovative and practical solutions. Living labs provide students with a relevant and real-world experience by directly engaging them with tools and technologies used in business. Furthermore, they facilitate interactive and cooperative learning in engineering education, functioning as a learning laboratory (Chapagain et al., 2023). This has been increasingly recognised for fostering the growth of soft skills such as leadership, teamwork, and effective communication, which are essential in the engineering profession (Shuman et al., 2005).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Towards a more sustainable ETSII engineering school

As is well known, sustainability is a pivotal aspect in today's society. As such, it is imperative for the School of Industrial Engineering (ETSII) to lead the charge, serving as a model for all its academic constituents: administrative and service personnel (PAS), professors and researchers (PDI), students, and society. Therefore, Sustainability is regarded as a fundamental axis within the Strategic Plan of the ETSII. In accordance with this commitment, the ETSII LivingLAB project was initiated as a pilot project is situated within the 5N building on the Vera campus of UPV and contributes to the broader UPV LivingLAB initiative. It charts a path forward and cultivates transferable expertise applicable to other educational institutions, universities, organisations, and key socio-economic sectors.

2.1 ETSII LivingLab project

The ETSII LivingLab project is located in the 5N building, exclusively dedicated to lectures, demonstrating good sustainability practices. Its estimated occupancy is approximately 1000 individuals, accounting for classroom capacity, occupancy levels, as well as administrative, service, and cleaning staff. Thus, daily small actions will significantly contribute to the overall sustainability of both the building and the school. The specific objectives of the ETSII LivingLab project are the following: carry out actions to improve the sustainability of the ETSII and to serve as a reference in the fight against climate change ;develop a demonstrator showcasing good practices in energy efficiency energy and decarbonization in one of the buildings of the ETSII; educate 80% of the school's faculty, staff, and students on how their actions affect the school's carbon footprint and work to reduce it; launch at least one challenge per year related to sustainability issues (water, waste, energy consumption, mobility, food, etc.) where the objectives are achieved by at least 80%. The project consists of 6 work packages (WPs), with WP1 ETSII SUSTAINABLE MANAGEMENT serving as the central hub for project management and coordination. WP2 DE-CARBONIZE-ETSII aims to calculate the carbon foot print of the school and to reduce it. To this end, a data acquisition system is developed, from which various sustainability Key Performance Indicators (KPIs) are calculated in real time. WP3 ETSII DEMONSTRATOR aims to develop a living lab-style environment that functions as both a teaching laboratory and a demonstration of effective strategies for addressing climate change. WP4 R^4 (Reduce+Reuse+Recycle+Renaturalize) initiative works to reduce water usage and waste produced, and supports the circular economy at ETSII. This WP also benefits from reducing energy use. As a pilot project, the school suggests adhering to all the UPV initiatives that support more sustainable mobility in the framework of WP5 MOBILIZ-ETSII. Finally, to reduce the CO_2 emissions of the ETSII, the needed steps are taken from a communicative and inclusive perspective, involving the entire ETSII community in the process, in WP6 ETSII-INTERCONNECT.

2024, Editorial Universitat Politècnica de València BY-NC-SA

The planned activities are scheduled to commence in March 2023 and conclude in September 2024 (a period of 18 months), with a possible extension into 2025. During this period, further activities will be conducted with the objective of demonstrating the project's outcomes and engaging with the ETSII community.

2.2 Multidisciplinary team

The project team comprises professors from the ETSII with expertise in electrical engineering, energy engineering, hydraulic engineering, ICT, computer programming, and automatic systems. Additionally, administrative and service personnel (PAS) from the maintenance and computer service of the ETSII are included to provide support during project execution. Specialised companies are currently responsible for the analysis and management of the measurement and data acquisition system (DAQsystem) at UPV. Naturally, the central services of UPV, such as infrastructure services, maintenance, and computer scientists (ASIC) and the the Environmental Unit of the UPV (UMA) also provide support. A continuous dialogue is maintained with these services. In order to foster the replicability of the solutions developed at both the city and campus levels, collaborating entities such as the Chair of Urban Energy Transition (CATENERG) of the UPV participate. The director of CATENERG leads the LivingLAB ETSII project as the deputy director of sustainable development of the ETSII.

2.3 Actions and initiatives carried out

The ETSII LivingLab aims to increase awareness and reduce the environmental impact of daily activities, while fostering a community committed to combating climate change. For this purpose, we have created a data acquisition and monitoring system called DAQsystem. This system monitors a range of data that impact sustainability and enables us to involve the entire ETSII community. By using 15 minutes real time measured data (total electricity and air conditioning consumption, water consumption, ambient temperature, and relative humidity in classrooms), we quantify the impact of each action taken to improve the building's sustainability. These measurements will be displayed on a large screen located in the hall of building 5N during the second semester of 2023-2024, as well as in the ETSII website. For developing such a DAQsystem, we opted for the TIG stack (Telegraf, InfluxDB and Grafana). This technology stack serves a robust solution for management and visualization of time-series data. Telegraf acts as a data collection agent, gathering information from multiple sources and sending it to InfluxDB. InfluxDB being a highly efficient time-series database that stores and organizes the data optimally, enabling fast and efficient access. Lastly, Grafana handles the visualization and analysis of the data, providing interactive dashboards and analytical tools. This stack stands out for the flexibility and scalability that provides, making it a solid foundation for an expansion of the project to the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

whole campus. The project faced some challenges inherent to developing it on a university campus. These challenges added complexity during the initial stages of the project, mainly related to permits to access remote real-time measurements stored in a SQL server. Table 1 presents the values for the initial key performance indicators (KPIs) on 29 January 2024. It should be noted that this list is subject to ongoing evolution, with the incorporation of new experimental measurements based on feedback from the ETSII community.

Table 1 – General KPIS of the ETSII LivingLab project

Dimension	Indicator	Value (Units)	Status
Energy	Total electricity consumption in the building	1070.0 kWh 0,2186 kWh/m² a 1,07 kWh/user	Real time measurement
Energy	Total electricity consumption due to air-conditioning usage in the building	421,7 kWh 0,0862 kWh/m² 0,4217 kWh/user	Real time measurement
Water	Total water consumption in the building	3.344 m³ 0,0033 m³/user	Real time measurement
Waste	Total amount of waste generated at the school	4190 kg organic 5810 kg paper 2090 kg plastic	Estimated with UMA data. To be measured in the near future.

Source: Own elaboration

Figure 1 presents an illustration of the ETSII LivingLab project DAQsystem for the KPIS for water and energy consumption on the 29th of January 2024 at the end of the day.

Fig. 1 –Example of display showing some KPIS of the ETSII LivingLAB project.

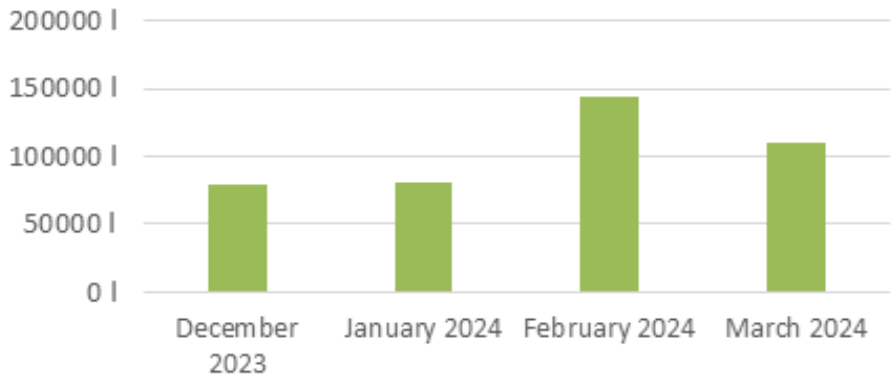


Source: Own elaboration

 BY-NC-SA

One of the most significant outcomes of the project to date is the implementation of real-time water consumption measurement in the 5N building. This allows for the differentiation of water consumption in the bathrooms on each floor of the building, as well as the fountains. The DAQsystem has resulted in enhanced building maintenance and water conservation, due to the ability to identify and address undetected leakages or stand-by energy and water consumptions. Furthermore, the data generated by the system can be employed to evaluate any refurbishment for reducing the water consumption. Figure 2 demonstrates the evolution of the total monthly water consumption from December 2023 until March 2024. It is evident that consumption levels are lower in December and March due to the holiday periods. The same situation arises in January when the facility is only used for examination purposes.

Fig. 2 –Water monthly consumption evolution in building 5N in 2023-2024.



Source: Own elaboration

As part of the impact generated by the project, the knowledge gained from the measurement and monitoring process is currently being transferred to the central services of UPV in order to replicate it in the rest of the buildings on campus. This illustrates the positive impacts and knowledge transfer that can be achieved through initiatives such as the ETSII LivingLab project, which serves as a testing ground for innovative solutions that can be replicated not only within the UPV campus but also to other institutions and society.

The developed DAQsystem is modular, allowing for the straightforward incorporation of data from new measuring devices. Prior to September 2024, the database will be made accessible to members of the ETSII community. This will facilitate the attraction of talent and the generation of new knowledge, as professors, researchers and students will have access to real, monitored data of the building that can be used for research activities and the development of final projects for degree, master and doctorate studies. Following a trial period, open access will be provided in 2025 to users outside the UPV, with the objective of enhancing the replicability of solutions developed and the transfer of knowledge to society. For instance, the city hall of Valencia has expressed interest in replicating this approach in an institutional building located in Valencia city (La Harinera), which is an old flour factory that

BY-NC-SA 2024, Editorial Universitat Politècnica de València

has been refurbished and converted into a space that aspires to become the new public entity of public innovation in the city of Valencia.However, we do not intend to undertake this project alone; our goal is to engage the entire ETSII community in the School's decarbonization process. As an example we organized the INDUSHack Living Lab (ETSII, 2023), from May 4 to 18 in 2023, with a toal of 42 registered students working in teams of 2-3 stduents each. It fostered collaboration and teamwork, while proposing innovative solutions to make organisations, such as ETSII, more sustainable and inclusive. This challenge, of a multidisciplinary nature, was framed in different SDGs: SDG 4, SDG 6, SDG 7, SDG 11, SDG 12 and SDG 13.

Finally, as part of the ETSII-INTERCONNECT project's WP6, the ETSII community demonstrated their commitment to sustainability through an awareness campaign, which featured sustainability messages (by ETSII management, professors and students) displayed every week from October 2022 to February 2023 on ETSII screens. This transformed the screens into a virtual sustainability agora for the ETSII community. This has a positive impact on society, as the ETSII members are also citizens. Consequently, behavioural change gained thanks to the ETSII LivingLab project could be kept and transferred to the city.

3. Conclusions and Proposals for further improvement

A LivingLab was developed in one of the buildings of the school of Industrial Engineering to involve students in real problems and increase environmental social awareness among the ETSII community. A DAQsystem was developed showing real time buildings' sustainability data. Future and ongoing activities in the ETSII living lab are: i) installation of 30 kWp of photovoltaics (PV) panels on the roof (April-May 2024) and comparison with a predictive model (July 2024); ii) energy audit (May-July 2024); iii) installation of sensor cameras to measure real time occupancy levels (under discussion with UPV legal service); iv) installation of prototype recycling garbage cans equipped with level sensors for a more efficient waste collection system (April-May 2024); v) creation of a student sustainability forum on ETSII social networks (May 2024); vi) include nature-based solutions (planned for 2024-2025) vii) show real time KPIs (September 2024) viii) preparation of 2 sustainability challenges (on 14th of March 2024; and on 30th of September 2024). The budget allocated today has been earmarked for the following activities: the PV installation, funded with NextGenerationEU funds and provided and installed by the Vice-Rectorate for Sustainable Development of Campus (approximately €50,000); the installation of sensors and programming of the DAQ system (€9,000); and four UPV student internship contracts (€12,000 per year).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Acknowledgements

This work was supported and hosted by the ETSII, at UPV. Authors would like also to thank Cátedra de Transición Energética Urbana- a chair funded by Ajuntament de València-Las Naves and Fundació València Clima i Energia, and the "Innovación y mejora educativa aplicada a los Objetivos de Desarrollo Sostenible en la ETSII" project (PIME/21-22/281), financed by Vice-Rectorate for Organization of Studies, Quality, Accreditation and Languages of the Universitat Politècnica de València.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Chapagain, MR, et al. (2023). Is a Living Lab Also a Learning Lab?—Exploring Co-Creational Power of Young People in a Local Community Food Context. *Youth,* 3(2), 753-776. https://doi.org/10.3390/youth3020049

Escuela Tècnica Superior de Ingeniería Industrial. (2023). Indushack Living Lab 2023, *Universitat Politècnica de València*. Available online: https://www.etsii.upv.es/noticia-es.php?id=1073

European Commission, Directorate-General for Research and Innovation. (2022). EU missions – 100 climate-neutral and smart cities. *Publications Office of the European Union*, https://data.europa.eu/doi/10.2777/191876.

Gomes, R., et al. (2017). Towards a Smart Campus: Building-User Learning Interaction for Energy Efficiency, the Lisbon Case Study. *Handbook of Theory and Practice of Sustainable Development in Higher Education, World Sustainability Series, Springer International Publishing,* doi 10.1007/978-3-319-47868-5_24.

Hossain, M., Leminen, S., Westerlund, M. (2019). A systematic review of living lab literature, Journal of Cleaner Production, 213, 976-988, https://doi.org/10.1016/j.jclepro.2018.12.257.

Mataix Aldeanueva, C., et al. (2017). Regeneración de campus para la creación de un laboratorio vivo de sostenibilidad ("living lab") en el Campus de Excelencia Internacional de Moncloa, *VII Congreso Universidad y Cooperación al Desarrollo,* Madrid, Spain, 668-679.

Shuman, L. J, Besterfield-Sacre, M., McGourty, J. (2005). The ABET "Professional Skills" Can They Be Taught? Can They Be Assessed?. *Journal of Engineering Education*, 94 (1), 41-54, https://doi.org/10.1002/j.2168-9830.2005.tb00828.x

Vice-Rectorate for Sustainable Development of Campus. (2022). UPV Living Lab. *Universitat* Politècnica de València. Available online: https://www.upv.es/entidades/vcampus/en/en-living-lab/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Teaching and Learning of Microgrids for Secondary School Learners – a Renewable Energy Sustainability Strategy for East African Communities

Paul Bogere[a], Alexander Belov[a], Katrin Temmen[a]

[a]Department of Electrical Engineering and Information Technology, Paderborn University, Germany

Abstract

Teaching and learning of microgrids for secondary school learners aged 14-18 is envisaged as a microgrid, and hence a renewable energy, sustainability strategy. Microgrids are decentralized energy systems that generate electrical energy from renewable energy sources. It is believed that with the acquisition of microgrid knowledge and skills from schools, this category of stakeholders retire to their homes and the communities can benefit from their acquired competencies. To this end, microgrid course materials for secondary school learners are developed, implemented and evaluated. Before the materials development, the course content was designed based on the secondary schools' physics syllabi from selected East African (EA) countries. The implementation and evaluation were done in a secondary school in Kenya. The implementation is a real learning situation of lessons designed for a physics class. Learners execute practical tasks using the supplied materials and acquire essential knowledge and skills related to microgrids. Evaluation of the course reveals successful microgrid knowledge transfer and increased learner motivation. According to self-assessments, participating learners acquired all knowledge and skills imparted during the microgrid course. Learners note that demonstrations and experiments are particularly effective in facilitating comprehension of the course content. Learners perceive the wiring exercise as the highlight of the course, evaluated with the greatest positive influence on motivation and interest among all included activities. The opportunity to wire circuits independently creates a sense of accomplishment.

Keywords: Knowledge transfer; Microgrids; Renewable energy; Sustainability.

How to cite: Bogere, P.; Belova, A. and Temmena, K. (2024) Teaching and learning of microgrids for secondary school learners – a renewable energy sustainability strategy for east african communities. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 128-136.
https://doi.org/10.4995/SEED2024.2024.19007

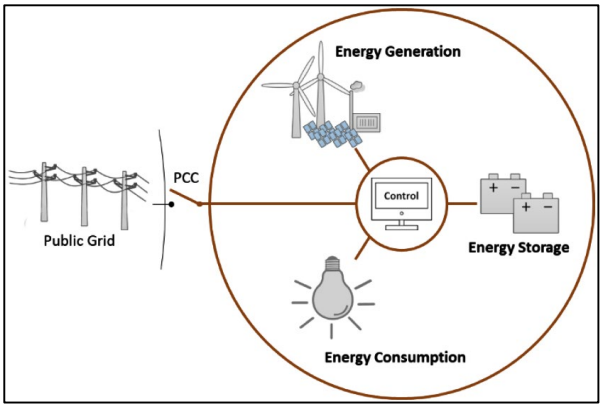
BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

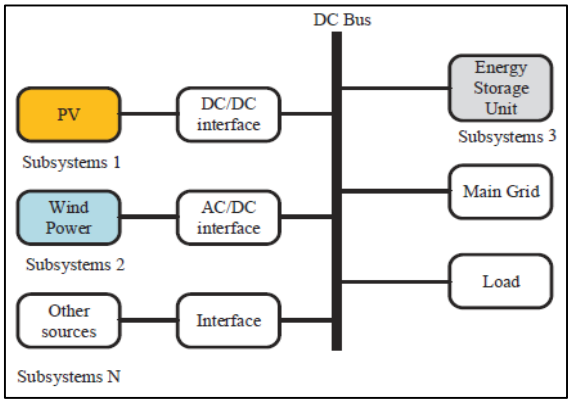
Access to electricity is a critical factor in the well-being and economic development of a country (Stern et al., 2018, p. 21). Therefore, inadequate electrical infrastructure has negative consequences for several sectors, ranging from engineering, healthcare, education and individual lives. One in ten people worldwide still do not have access to electricity, which equates to approximately 700 million people, who are predominantly found in Sub-Saharan African regions (United Nations, 2020).

To improve electrical energy access, therefore, microgrids are an optimal solution in many rural areas of developing countries. Microgrids are decentralized grid systems that can generate, store, and distribute electrical energy within defined electrical boundaries. Microgrids can either operate in connection to a public maingrid or an island mode as illustrated in figure 1. Microgrids can provide electricity for entities ranging from small households to commercial establishments, and institutional settings in communities.

Fig. 1 – Illustration of a microgrid



Source: Authors



Source: (Alzahrani et al., 2017, p. 102)

Ensuring the sustainability of microgrids is vital. One of the sustainability avenues is to ensure the availability of trained local capacity to design, construct, operate, repair and maintain microgrids. Local capacity can be built through training secondary school learners, consumers of electrical energy, and BSc electrical engineering students (Bogere, Bode, et al., 2023a, 2023b; Bogere, Temmen, et al., 2023). Training of secondary school learners, therefore, about microgrids and hence renewable energy is in the right direction of contributing to a trained local workforce. This is because secondary school learners can apply the microgrids' knowledge and skills acquired from schools in their communities. To this end, microgrid course materials for secondary school learners are developed, implemented and evaluated.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Methodology

An empirical approach is used to analyze secondary schools' physics syllabi from Kenya, Tanzania, and Uganda. This guides the development of the microgrid course content for secondary schools in EA. The course goal, objectives, and intended learning outcomes (ILOs) based on the revised Bloom's Taxonomy are itemized (Ferris & Aziz, 2005; Krathwohl, 2002).

The course materials including work and information sheets, teacher's guide, demonstrations and experiments, and practical exercises are developed. Figures illustrating technical concepts in the course materials are developed and adapted to the target group, both from a didactic point of view and in terms of design.

The implementation of the developed microgrids course is done by teaching a total of 33 form four female learners aged 18, on average, across a total of eight lessons. The teaching and learning took place at one secondary school located in rural western Kenya.

For evaluation of the course materials, non-experimental quantitative surveys are conducted by using checklists and feedback questionnaires mainly consisting of closed questions. The survey is divided into a predictive and a retrospective evaluation. The predictive evaluation is conducted before the implementation of the materials. For the retrospective evaluation, a feedback questionnaire is filled out by the learners at the end of each of the eight lessons. Finally, the physics teacher of the class fills out the same checklist as well.

3. Results

The teaching of the microgrids course to secondary school learners is accomplished through 8 lessons under 5 topics. A summary of the topics, lessons, duration and the corresponding selected intended learning outcomes (ILOs) are presented in table 1. The purpose of the first lesson is to introduce the microgrids course, share the information sheets and worksheets with the learners, and perform a pre-survey. The pre-survey is intended to record learners' interests and motivation towards physics as a subject and the microgrids course in particular plus, how they wish to learn. One of the pre-survey questions to check whether the selected methods and media correspond to the learners' preferences is "Which media do you prefer to learn at school?". This is a multiple-choice question and results indicate that learners prefer laptops, tablets, and computers with an evaluation of 76% compared to 15% for information and worksheets, 9% for black and white boards, 6% for smartphones, and 3% for textbooks.

The actual content of the microgrids course is contained in and taught starting from the second microgrids overview lesson through to the seventh lesson – the practical on domestic electrical wiring. Retrospective evaluation is performed at the end of each lesson by learners. For example; the microgrids overview lesson, is evaluated and the results are indicated in figure 2.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Topics, lessons, duration and ILOs for teaching microgrids to secondary school learners

Topic	Lesson	Duration (Minutes)	Intended learning outcomes
Microgrids overview	Introduction and pre-survey	30	
	Microgrids overview	65	List components of a microgrid. Explain the operation of a microgrid. Discuss the advantages of microgrids. Discuss renewable sources of energy.
Basic electric theory	Basic electric theory	70	Define electric current, voltage, and resistance. Measure voltage and current in simple electric circuits. Construct simple electrical circuits. Identify symbols used in electrical circuits.
Solar PV systems	Solar cells and PV modules	70	Explain solar cells' principle of operation. Construct solar modules. Determine the capacity of solar modules.
	Sizing of a solar PV system	70	Discuss the terms "string" and "array". Manipulate the series and parallel connections of solar PV modules for a desired system output. Design a simple PV solar home system (SHS) by determining: daily energy consumption; required battery capacity; size of solar modules, inverter, and charge controller. Model a microgrid system.
Domestic electrical wiring	Theory on domestic electrical wiring	80	Identify accessories used in domestic electrical wiring Practice health and safety of electrical wiring guidelines. Explain the purpose of circuit breakers in electrical installations Sketch an electrical wiring circuit diagram of a simple domestic house.
	Practical on domestic electrical wiring	115	Interpret electrical wiring circuit diagrams. Perform practicals of electrical wiring circuits for simple domestic houses
Discussion and final evaluation	Post-survey	40	Discuss the advantages of a microgrid over a SHS.

Source: Authors

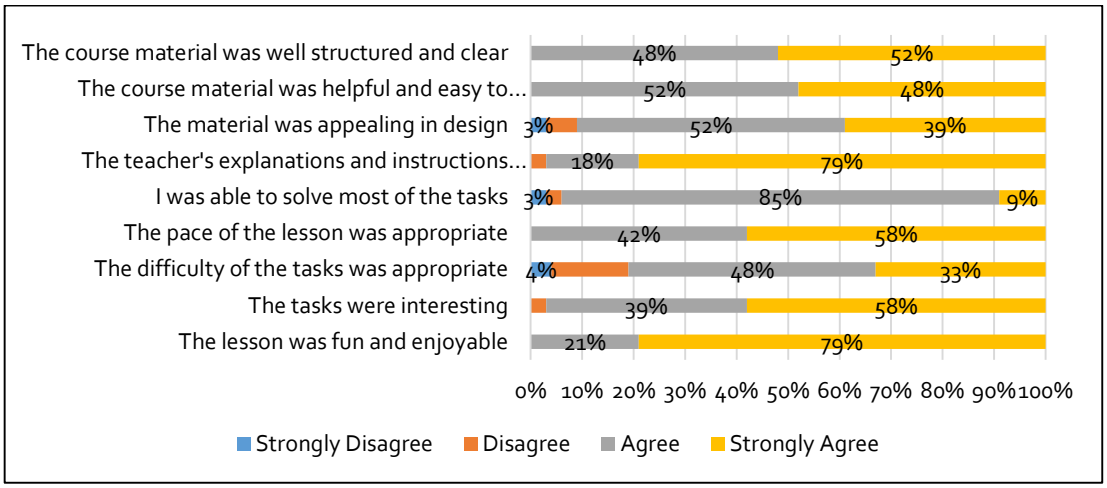
Generally, the materials of the microgrids overview lesson and the teaching are rated high as evident in figure 2. According to the evaluations, the materials are well-structured, clear, helpful and easy to understand. To be specific, 52% of the learners strongly agree that "the course material was well structured and clear" and 48% agree with the statement. On the other hand, 48% of the learners strongly agree that "the course material was helpful and easy to understand" compared to the 52% who agree with the statement. However, 3% of the respondents strongly disagree that the material's design is appealing.

The positive attitude towards the course is also reflected in the learners' comments regarding what they liked about the microgrids overview lesson in particular. One learner commented that she likes "the fact that those in remote areas can be able to use the microgrid in sustaining their day-to-day lives. I love the microgrid[s] course". Another learner commented that "I liked to see how [a] microgrid works and also how it is used to store energy in the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

battery" and another that she likes "the fact that I got to know more about electricity". These positive comments are representative of the learners' great interest in the topic of microgrids and electrical engineering.

Fig. 2 – Learners' evaluation of the microgrids overview lesson



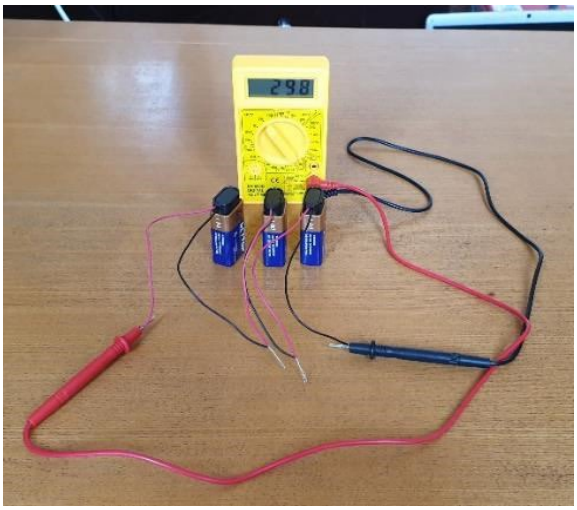
Source: Authors

It is vital to note that demonstrations and experiments are paramount in enhancing learners' understanding of rather would be abstract and complex concepts. Demonstrations and experiments ensure a learning environment that provides students with a primary and immediate sensory exploration of experiences. As such, all lessons have demonstrations and/or practical experiments. As an example, figure 3 presents (a) a multimeter and three 9 V block batteries used in lesson three to explain the measurement of voltage and current. The learners are given a chance to arrange 9 V block batteries in series and to measure the voltage by themselves. (b) components of the solar system including a solar module, battery, solar charge controller and inverter used in lesson five. Learners work in groups to prepare presentations on one of the components assigned to them. At the end of the presentations, learners work together to wire a solar system and energise the classroom TV.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 3 – Lessoon 3 and lesson 5 demonstratin materials

a) Multimeter and three 9V block batteries



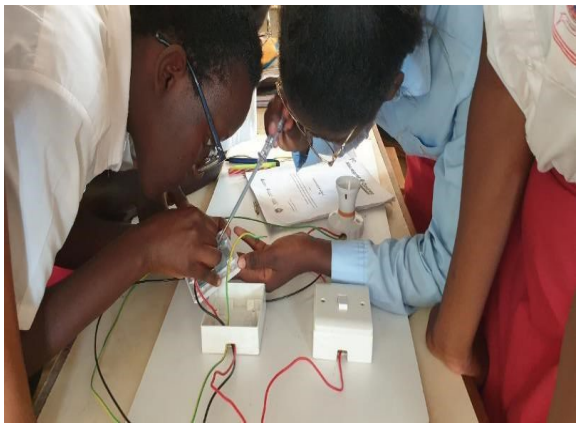
b) Components of a solar system



Source: Authors

Another notable lesson is the seventh lesson, a practical lesson on domestic electrical wiring following a theoretical one, that transfers basic domestic electrical wiring skills. The learners perform electrical wiring circuits, on exercise boards, as indicated in figure 4. Some of the accessories used in the practical exercise include 16 A circuit breakers, lamp holders, 20 A bar connectors, 1.5 mm^2 single flexible conductors, single wall sockets, electric wall plugs, one gang one-way switches, and appliances such as LED bulbs among others.

Fig. 4 – Learners during a practical lesson on domestic electrical wiring, boards before & after the practical



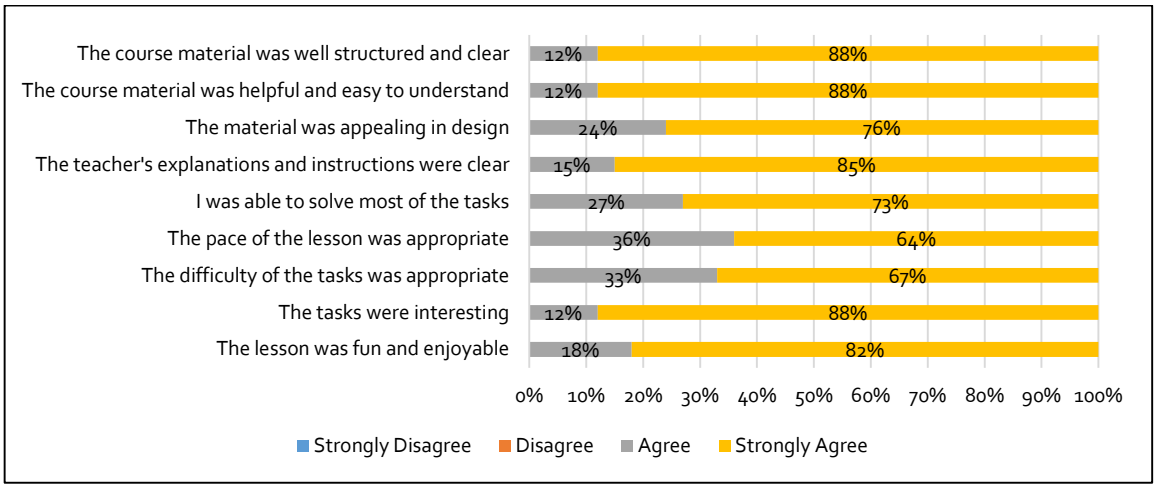


Source: Authors

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Evaluation of the course's practical lesson on domestic electrical wiring is done and the results are shown in figure 5. It is interesting to note that learners either agree or strongly agree with all statements of the evaluation.

Fig. 5 – Learners' evaluation of the practical lesson on domestic electrical wiring



Source: Authors

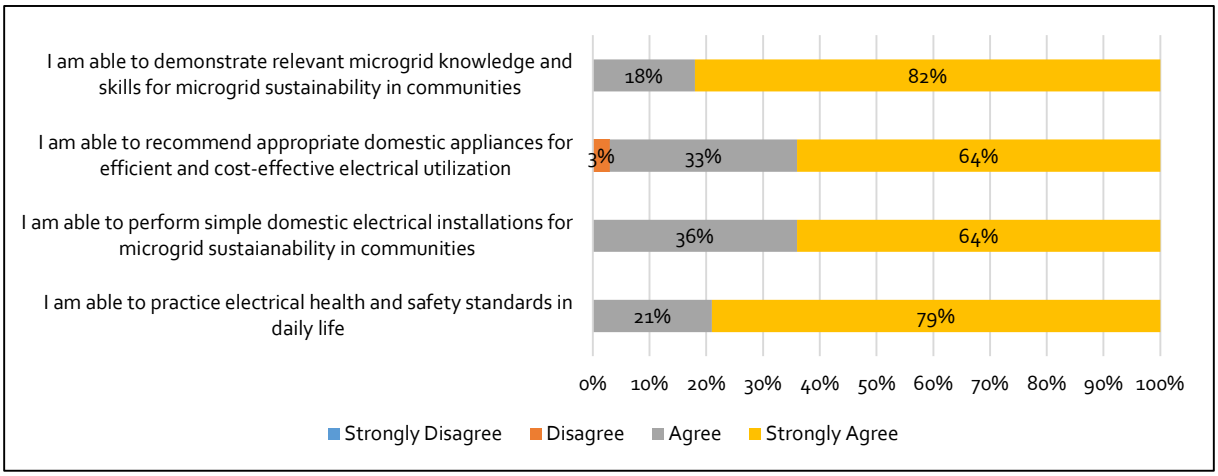
All other lessons, and the corresponding course materials, are equally implemented and evaluated by the learners. In lesson eight, consideration is made of using a microgrid instead of an SHS hence, a discussion regarding the advantages of a microgrid compared to an SHS is held. Reflection of the entire microgrids course is done and a post-survey is conducted. Learners provide feedback regarding achieved competencies as represented in figure 6.

Generally, the learners embraced the microgrids course. Referring to the responses in figure 6, the intended objectives are achieved as revealed by the following learners' excerpts (1) "I enjoyed the lesson when we were assigned group work for researching the main components of a microgrid." (2) " .... were assigned homework to make presentations which helped in understanding the course." (3) "I am amazed that I can do connections and even explanations on how electrical appliances work." (4) "I liked the fact that I was able to do wiring myself." The excerpts also reveal that other skills such as teamwork and effective communication are equally enhanced and these are vital in the world of work.

However; there are some critics as well arising from the short duration of the course. Not being able to write many notes is another criticism. The critic reveals that writing notes can enable learners to easily understand and recall content whenever revision is done. The physics teacher in charge of the class that was taught the microgrids course also performed a retrospective course evaluation. The teacher indicated that (1) some materials are costly and (2) more time should be added to the course.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 6 – Learners' self-assessment indicating achieved competencies



Source: Authors

4. Conclusion

In the development of the microgrid course materials for secondary school learners, information and worksheets, teacher's guides, demonstrations, experiments, and practicals are developed. The course materials are integrated into a physics class at a girls' secondary school in Kenya over a period of eight lessons. The lessons centre on a practical scenario in which learners are asked to design and implement a solar power system for a small business. Following implementation, each of the lessons is evaluated.

Subsequent evaluation confirms that the developed course materials not only facilitate the microgrids' knowledge transfer and skills but also exert a strong positive effect on engagement. According to the feedback, the information and worksheets, and teacher's guide are well structured, helpful, easy to understand, and appealing in design. The demonstrations and experiments contribute significantly to learners' understanding of the course content. The practical wiring exercise, the highlight of the microgrid course, received positive feedback from the learners. After successfully solving problems with the boards and tools, the learners report a feeling of accomplishment and boosts to self-confidence and motivation.

Results of the overall microgrids course evaluation reveal that microgrid knowledge transfer is achieved. Learners indicate the ability to demonstrate microgrids knowledge, recommend appropriate domestic appliances, perform simple domestic electrical wiring, and practice electrical health and safety. However; one of the envisaged shortcomings of the implementation is that the evaluations are not based on formative and summative assessment methods to verify knowledge transfer based on acquisition of ILOs but rather on surveys focusing on materials design and delivery of lessons. That notwithstanding, microgrids knowledge is transferred and this contributes to the trained local capacity. With the trained local capacity, it is envisaged that microgrids' sustainability is improved. Therefore; since renewable energy sources are considered in the generation subsystem of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

microgrids, teaching and learning of microgrids for secondary school learners is a renewable energy sustainability strategy.

Acknowledgements

The authors acknowledge the secondary school in Kenya for enabling the implementation and evaluation of the microgrid course developed materials to be accomplished. In the same way, the authors sincerely appreciate Germany's Federal Ministry of Education and Research (BMBF) for the financial support extended. BMBF funds this research under the "Client II" programme and the funding reference number is 03SF0607B. The research is conducted under the Africa: Research and Teaching Platform for the Development of Sustainable Modular Grids for Grid Stability (A: RT-D Grids).

Conflicts of interest

The authors declare that there are no known competing interests, financial or otherwise personal relationships, that influenced the results presented in this paper.

References

Alzahrani, A., Shamsi, P., Ferdowsi, M., & Dagli, C. (2017). Modeling and Simulation of a Microgrid Using Feedforward Neural Networks. *The 6th IEEE International Conference on Renewable Energy Research and Applications (ICRERA 2017)*, 101–106.

Bogere, P., Bode, H., & Temmen, K. (2023a). Skill Sets for Microgrids Sustainability - The Case of East Africa. IEEE AFRICON Conference.

Bogere, P., Bode, H., & Temmen, K. (2023b). Work-In-Progress: Development of a Virtual and Interactive Microgrids Learning Environment for Microgrids Sustainability – The Case of East Africa. In M. E. Auer, W. Pachatz, & T. Rüütmann (Eds.), Learning in the Age of Digital and Green Transition. ICL 2022. Lecture Notes in Networks and Systems (633rd ed., Vol. 1, pp. 671–679). Springer Nature.

Bogere, P., Temmen, K., & Bode, H. (2023). Knowledge Transfer Concepts for Microgrids Sustainability - The Case of East Africa. IEEE Global Engineering Education Conference (EDUCON), 2023-May, 1–6. https://doi.org/10.1109/EDUCON54358.2023.10125208

Ferris, T., & Aziz, S. M. (2005). A Psychomotor Skills Extension to Bloom's Taxonomy of Education Objectives for Engineering Education. Exploring Innovation in Education and Research, March, 1–5. http://slo.sbcc.edu/wp-content/uploads/bloom-psychomotor.pdf

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. Theory Into Practice, 41(4), 212–219.

Stern, D. I., Burke, P. J., & Bruns, S. B. (2018). The Impact of Electricity on Economic Development: A Macroeconomic Perspective. International Review of Environmental and Resource Economics, 12(1), 85–127. https://doi.org/10.1561/101.00000101

United Nations. (2020). United Nations. https://www.undp.org/energy/our-work-areas/energy-access/access-electricity

2024, Editorial Universitat Politècnica de València BY-NC-SA

Facilitating evaluation and innovation of regional centers of vocational excellence in sustainable energy education

Evelien Ketelaar [a], Angelique Ruiter [b], Lenny van Onselen [b], and Yvette Lanting [c]

[a] Research group Vocational Education, HU University of Applied Sciences, The Netherlands
[b] Research group Co-design, HU University of Applied Sciences, The Netherlands
[c] CoE Smart Sustainable Cities, HU University of Applied Sciences, The Netherlands

Abstract

Five European regions collaborate to improve sustainable energy education in their regions in a four-year project. Collaborating partners in these regions do this through setting up and developing so called centres of vocational excellence (CoVE). A CoVE is a regional ecosystem where vocational and higher education, companies, and other organisations work together on education, innovation, and research in a rapidly developing field, in this case, sustainable energy education (SEED). This paper describes an approach to facilitate the development and innovation of CoVEs. A quick scan was developed, consisting of various tools and templates. It helped CoVEs to gain insights into the stakeholders involved in their CoVE, the maturity of their CoVE regarding teaching and learning, cooperation and partnerships, and governance and financing, and the developmental potential of their CoVE. Further development of the CoVEs was stimulated and guided by introducing codesign as a way of working on innovation. Altogether, this approach showed similarities and differences between the five CoVEs and gave opportunities for exchanging knowledge, experience and inspiration.

Keywords: vocational excellence; regional innovation; education; CoVE.

How to cite: Ketelaar E.; Ruiter A., van Onselen L. and Lanting, Y. (2024) Facilitating evaluation and innovation of CoVEs in sustainable energy education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 137-145. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

When collaborating transnationally, reflecting on shared challenges and approaches towards sustainability is key (Caniglia et al., 2017) to providing excellent vocational education on sustainable energy towards a fossil fuel-free Europe. CoVE SEED is an international collaboration of five regions in Europe: Western Macedonia (Greece), Valencia (Spain), Bochum (Germany), Turku (Finland) and Utrecht (the Netherlands). These five regions are collaborating in the Erasmus+ programme to develop sustainable energy education through regional CoVEs. In this project, we define a CoVE as a regional network of partners that "develop local 'skills ecosystems' to provide high quality vocational skills to young people and adults, and contribute to regional development, innovation, industrial clusters, smart specialisation strategies and social inclusion." (European Commission, n.d.). Partners in the CoVEs are, among others, vocational education and training schools (VET), universities of applied sciences, companies, municipalities, provincial governments, and foundations. Each region has several good practices of sustainable energy education that form the starting point of the CoVE and which are being further developed and expanded in the CoVE SEED project. Representatives of the project's regions meet regularly online and offline to learn from and with each other. During these meetings, for example, knowledge and experience are exchanged, good practices are shared, and methods and tools for developing COVEs are introduced.

To support the five CoVEs in their further development and innovation, the authors cocreated an approach to evaluate and reflect upon the extent to which CoVEs have reached a level of maturity and to support further development of CoVEs through codesign. This paper describes this approach and shares insights and lessons learned.

2. Development process and use Quick Scan CoVE Maturity

The Quick Scan CoVE Maturity was developed through an iterative design process. The quick scan aims to gain an overview of a CoVE's maturity in a relatively short time, giving insights that can be used to formulate a regional development plan to further develop the CoVE. The quick scan was adapted from CoVE Maturity Model (European Commission ET 2020 working group on VET, 2019) and using elements from the European Training Foundation CoVE self-assessment tool (ETF, 2022), a public-private partnership model from Katapult (2020), and elements of codesign. Furthermore, two sustainability researchers added specific criteria about sustainable energy education.

During a train-the-trainer workshop the CoVE SEED region leaders were guided through the steps of the quick scan and tried out developedsupporting materials. After that, representatives per region conducted a regional quick scan in a workshop, using the provided instruction manual and supporting materials.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 1 – Steps of the Quick Scan



Source: Own elaboration

The quick scan contains several steps, see Figure 1. The regional leader did a preparation step (step 1) which consisted of collecting sources about one's own CoVE (project plans, vision, examples, etc.), selecting and preparing the participants for the workshop, and go through workshop materials. Steps 2 to 5 were executed during a regional workshop. For this purpose, supporting tools were developed. The tool for step 2 is a stakeholder mapping approach based on Allee (2008) to create an overview of the stakeholders within the CoVE and their relations, interests, and influence. The tool for step 3 is a set of discussion cards with questions per theme within three overarching categories: teaching and learning, cooperation and partnerships, and governance and finance (cf. European Commission ET 2020 working group on VET, 2019; see Table 1). The questions were used to facilitate a discussion with the aim of coming to a better and shared understanding within the CoVE to help decide what topics should be tackled. The discussion cards also facilitated the conversation between different participants of a CoVE, such as teachers and policymakers, to help clarify the different roles within the CoVE. The results of these discussions were noted down in a form structured around the themes. After the discussion, the participants were asked to use the next tool in step 4: the Matrix Maturity Model. For each of the 13 themes within the overarching categories teaching and learning, cooperation and partnerships, and governance and finance (see Table 1), regions placed their CoVE within one of the developmental phases:

1) Exploration: exploring the possibilities of developing VET in the region to working as a CoVE.
2) Setting up foundations: improve VET in connection with the labour market.
3) Developing added value: engage with regional strategic development and collaborating with a wide range of stakeholders.
4) Achieving excellence: cocreate local skills ecosystems, local innovation and regional development, with a strong international dimension. Build a "self-reflexive CoVE".

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1 – Categories and themes Quick Scan CovE Maturity

Category	Theme
Teaching and learning	Responsive curriculum and programmes
	Life long learning
	Innovative pedagogy
	Education and training pathways
	Professional development teachers
	Quality and validation
Cooperation and partnerships	Partnerships
	Nature of partnerships
	Knowledge creation
	International activities
Governance and financing	Organisation
	Funding – how
	Funding - use

Source: Own elaboration

The original CoVE maturity model (European Commission ET 2020 working group on VET, 2019) contains only the last three phases. Yet, after piloting the quick scan, we learned that some of the participating CoVEs were still exploring the possibilities on one or more of the themes and were struggling with how to set up a CoVE. Therefore, the first phase (Exploration) was added to the matrix, allowing the regions to express they were exploring the possibilities to develop sustainable energy education in their region towards working as a CoVE. A reflection canvas supports the fifth step, bringing together the insights from the previous steps, stimulating reflection, and collecting insights for the follow-up: preparing a development strategy and a development plan.

3. Facilitating CoVE regional innovation through codesign

To facilitate further development of the CoVEs, following the use of the Quick Scan CoVE Maturity, each region formulated a regional strategy for their CoVE. For this purpose, a template was developed, building on the last step of the quick scan (the reflection canvas). This template contained different aspects of building a strategy plan for the CoVEs; it focussed on challenges, opportunities, aspirations, points of improvement, focus areas and activities to achieve the CoVE's vision. Next, the five regions draft regional development plans. These plans contain an analysis of the current situation, setting goals for development and a strategy for collaboration and alliances.

To support the regions in their process of jointly formulating a development strategy and development plan, codesign was introduced to the CoVE SEED project. Design thinking is a

2024, Editorial Universitat Politècnica de València BY-NC-SA

way of thinking practiced by designers. Brown (2009) introduced the term to bring the 'designerly' way of thinking to other businesses and professions. Design thinking has become a popular term and is adopted by all sorts of professions. Design *doing* is the next step; not only adopt the way of thinking, but also apply design techniques to work together on complex challenges. Codesign involves people in design doing, such as people from the target group, professionals, experts and other stakeholders. Codesign uses specific design techniques to empathise with stakeholders and involve people to cocreate solutions. To apply codesign in the CoVE SEED project, a manual containing the design thinking approach (Brown, 2009; Van Boeijen et al., 2020) and advanced codesign methods to map complex systems (e.g. van Gessel et al., 2018; Sanders & Stappers, 2012; Sevaldson & May, 2022) was compiled, and a codesign workshop was held during a transnational meeting with the CoVE SEED consortium. In the workshop, codesign principles and the design thinking approach were explained and an advanced codesign method was applied.

4. Insights

The materials the regions handed in after using the Quick Scan CoVE Maturity, the observations of the workshop leaders and minutes from regional and transnational meetings were used to gain some insights into the usefulness and results of the approach.

The Quick Scan CoVE Maturity appeared to be useful for a region to gain insights into the stakeholders involved in their CoVE, the maturity of their CoVE regarding teaching and learning, cooperation and partnerships, and governance and financing, and the developmental potential of their CoVE. The regions representatives appreciated the train-the-trainer workshop and the materials provided. Overall, it was a good starting point for developing their regional strategies and development plans. Also, it gave opportunities for exchanging knowledge, experience and inspiration within the CoVE SEED consortium.

Several lessons can be learned from the results of the quick scan. Concerning the stakeholders, the regions were mainly satisfied with the number and kind of stakeholders formally being part of their CoVE. In different kinds of activities CoVE partners and stakeholders collaborate, such as research and development and education and training. Several CoVEs mentioned strong connections with important stakeholders outside of their CoVE, being of importance to the CoVE. The following lessons emerged from the stakeholder analysis of these five CoVEs:

1. Within the CoVEs, interactions and activities between stakeholders are often bilateral, so one stakeholder interacts with one stakeholder and not with a group of stakeholders. Also, activities tend to be fragmented, for example a one-time project. A development goal could be to start operating more as a learning community with a

BY-NC-SA 2024, Editorial Universitat Politècnica de València

joined vision and strategy eregarding to the CoVE and SEED in particular, with all stakeholders feeling responsible for it.

2. All CoVEs detected they need to (re-)activate some of the stakeholders that previously agreed to participate in the CoVE or extend the CoVE with other kinds of partners. In other words, it is important to keep all partners in a CoVE active and involved, to get SEED in a region at a higher level.
3. In several regions cooperation and partnerships are mostly based on individual projects, personal relationships, or warm contacts through other projects. This can be a possible weakness in case individuals leave the project and pose a risk in continuing collaboration at the long term. These things call for formalizing partnerships with clear goals and long-term planning.

Concerning the CoVEs' maturity, most CoVEs stated they are in different developmental phases within one category. For example, being in the exploration phase or setting up foundations phase with regard to lifelong learning, while already in the developing added value phase or achieving excellence phase with regard to innovative pedagogy. Also, for some CoVEs it was problematic to rate their CoVE as one whole, as parts of the CoVE (for example, a specific project or course) are more mature 'within specific themes than other parts of the CoVE.

Looking at the Teaching and Learning category (six themes) it stands out that none of the CoVEs consider themselves in the exploration phase on any of the themes within this category. Most CoVEs rate themselves in the setting up foundations phase for the themes 'responsive curriculum and programmes', 'lifelong learning', and 'education and training pathways'. For the themes 'professional development teachers' and 'quality and validation' most CoVEs rate themselves as developing added value. It can be concluded that overall, the CoVE SEED regions are well on their way in the area of teaching and learning, but there are still challenges that regional partners could address in the upcoming years.

During the codesign workshop, deeper insights came forward with regard to these challenges. The participants discussed that it is difficult to develop curricula for vocational education that match the requirements of the energy sector, even though they have strong partnerships with the energy sector. The challenge behind this problem is that - in this case in the Netherlands - the energy sector is subject to quick changes in national policies and fierce competition. Furthermore, vocational education has to deal with considerably strict national requirements for VET-education. Therefore, it is difficult to be highly responsive to the needs of the energy sector. A solution could be found in VET-institutions codesigning modular education together with the energy sector to be able to adapt quickly to these changes.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

With regard to Cooperation and Partnerships (four themes) the image is somewhat different. Most CoVEs consider themselves in the developing added value phase for the four themes. However, for each theme there areone or two CoVEs also rated themselves in the exploration phase. One CoVE is achieving excellence when it comes to 'knowledge creation' which means, amongst other things, that they have a coherent and well-coordinated approach to partnerships, play leading roles in places like innovation hubs and business incubators where their students have opportunities to engage in activities, and have new knowledge creation linked to organized research programmes.

In the codesign workshop, particpants of one of the CoVEs brought forward that the curriculum on energy education in the VET schools in their region need to be updated. The underlying problem is that the VET schools need to be collaborating with the energy sector. Codesign methods can be used to connect VET schools with the energy sector. In other words, this CoVE should focus first on strengthing collaboration and partnerships with the energy sector before they can improve their education.

Finally, the category Governance and Financing (three themes) can be considered a focus area for the development of most of the CoVE SEED regions, as the three underlying themes are mostly rated as exploration or setting up foundations. Most CoVEs lack a clear and future-proof organization structure, rely on ad hoc resources instead of sustainable funding and use their funding mostly to implement short term projects to address specific problems. However, one CoVE rates itself as achieving excellence with regard to how they have arranged their funding, meaning they have managed to implement sustainable funding models involving strong and reliable contributions from the private sector. These CoVEs could inspire other CoVEs as a good practice.

5. Concluding remarks

The Quick Scan CoVE Maturity gave the participating regions useful insights regarding the developmental potential of their CoVEs on sustainable energy education. To keep reflecting upon the development of the CoVE and stay sharp with regard to the stakeholders involved it is advisable to repeat the regional workshop every one or two years. Also, it is important to involve different representatives from the CoVE's partners in this process, as each of them may have a different point of view and experience with regard to teaching and learning, cooperation and partnerships and governance and finance.

Although the Quick Scan CoVE Maturity is organised around three overarching categories, during the different meetings we noticed that they are interlinked. For example, energy education will be improved when collaboration with the energy sector is strengthened through new partnerships and setting up a good governance structure. A way to approach this, can be by implementing a codesign approach. Involving all partners and discussing

BY-NC-SA 2024, Editorial Universitat Politècnica de València

different points of view and setting clear goals can help to build strong and enduring relationships between them (European Commission ET 2020 working group on VET, 2019).

Furthermore, the CoVEs all have opportunities to further develop and innovate their CoVE and sustainable energy education in their regions. Therefore, learning within and between regions should be stimulated and facilitated. Further research could focus on the processes of regional learning and transnational learning in the context of sustainable energy education, giving more insights into how to facilitate and deepen these learning processes.

Acknowledgements

This project has received funding from the European Union's EACEA.A - Erasmus+, EU Solidarity Corps under grant agreement No 101056147. The authors would like to thank the participants for applying the tools, Tijmen de Jong for cocreating with us the tools of the Quick Scan COVE Maturity as intern at research group Co-Design, and Esther Wijma for giving feedback on a previous version of this paper.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Allee, V. (2008). Value network analysis and value conversion of tangible and intangible assets. *Journal of intellectual capital*, *9*(1), 5-24. https://doi.org/10.1108/14691930810845777

Brown, T. (2009). *Change by design: How design thinking transforms organizations and inspires innovation.* Harper Collins Publishers: New York.

Caniglia, G., Luederitz, C., Groß, M., Muhr, M., John, B., Withycombe Keeler, L., von Wehrden, H., Laubichler, M., Wiek, A., & Lang, D. (2017). *Transnational collaboration for sustainability in higher education: Lessons from a systematic review. Journal of Cleaner Production,* 168, 764-779. https://doi.org/10.1016/j.jclepro.2017.07.256.

European Commission, ET 2020 Working Group on Vocational Education and Training. (2019). Mapping of Centres of Vocational Excellence (CoVEs).

European Commission. (n.d.). *Centres of Vocational Excellence.* https://ec.europa.eu/social/main.jsp?catId=1501

European Training Foundation (2022). *ENESAT22 – EFT Self-Assessment Tool for Excellence.* https://www.etf.europa.eu/en/what-we-do/self-assessment-centres-vocational-excellence

Katapult (2020). Fasemodel publiek privaat samenwerken in het beroepsonderwijs. https://www.wijzijnkatapult.nl/fasemodel-en-typologieen-van-publiek-private-samenwerking/

2024, Editorial Universitat Politècnica de València BY-NC-SA

Sanders, E.B.N., & Stappers, P. J. (2012). *Convivial toolbox: Generative research for the front end of design.* Bis Publishers: Amsterdam.

Sevaldson, B., & May, C. (2022) How to Gigamap. (Retrieved from https://systemsorienteddesign.net/how-to-gigamap/ dd 22-09-2023).

Van Boeijen, A., Daalhuizen, J., & Zijlstra, J. (Eds.). (2020). Delft Design Guide: Perspectives – Models – Approaches – Methods. Bis Publishers: Amsterdam.

Van Gessel, C., Van der Lugt, R., & De Vries, R. (2018). Socionas: Bringing the systemic view into the design for health and sustainability. Published in: Proceedings of Relating Systems Thinking and Design, RSD7.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Context-Sensitive Multidisciplinary Curriculum for Sustainable Energy Access Education

Ogheneruona E. Diemuodeke[a,c], Briggs[a,b] and Mohammed M. Ojapah[a,c]

[a] Department of Mechanical Engineering, Faculty of Engineering, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

[b] Technology Park, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

[c] Energy Technology Institute, Faculty of Engineering, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

Abstract

The energy access sector of sub-Saharan Africa (SSA), especially the mini-grid, is very large and is looking for the right skills to shape it optimally. However, there are fears in many quarters of SSA regarding the technical capacity to drive the huge opportunity the renewable energy access sector offers. Therefore, this paper presents the procedure for the development of a context-sensitive and globally recognized curriculum (MSc Energy Access and Renewable Energy Technology programme) to drive capacity building around the renewable energy access sector in order to provide local-sensitive innovative energy solutions for socio-economic development. In this context, capacity building is the development of a set of skills and competencies to effectively provide context-sensitive innovative energy solutions and an impeccable institutional framework to effectively implement and manage the innovations. The curriculum developed emphasised technical competencies, policy analysis, political economy of rural livelihood, gender mainstreaming, entrepreneurship and commercialisation, and environmental sustainability as the pillars driving the delivery. It is hoped that proper implementation and support by critical stakeholders will eliminate the ugly experience of Nigerians in the oil and gas sector during its business evolution.

Keywords: sustainable energy education; capacity building; multidisciplinary curriculum development; renewable energy; energy access

How to cite: Diemuodeke, E.O.; Briggs, T.A. and Ojapah, M.M. (2024) Context-Sensitive Multidisciplinary Curriculum for Sustainable Energy Access Education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 146-152. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Historically, there exist five innovation revolutions, namely water (1st), steam (2nd), coal and electricity (3rd), oil and gas (4th), and digital technology (5th). However, the current climate crisis and the need to drive the digital revolutions would progress into the sixth innovation revolution. The energy transition (the development away from fossil-based energy sources) has been tipped as the potential epicentre of the sixth innovation revolution (Newman, 2020). The steady rise in global atmospheric temperature relative to the preindustrial revolution and its catastrophic consequences (an allusion to climate change) has elevated the clamour for the need to decarbonise the global economy (Abbass, et al. 2022). The growing acceptance of renewable energy and the steady decline in the cost of renewable energy conversion technologies make renewable energy one of the most effective techniques for achieving sustainable development (Solarin, 2022). In this regard, nations globally are prioritising adopting renewable energy to restructure their industries and the energy sector to promote green growth. The restructuring of the industry sector to align with the green energy supply and the application of digital technologies will drive the sixth innovation revolution (the kernel of the Fourth Industrial Revolution). But the question is, is Nigeria (Africa in general) well-positioned to navigate the energy revolution terrain to adequately respond to the sixth innovation revolution, and economic and wellbieng induced local energy challenges? It is imperative to note that the energy access market, especially the mini-grid, is very large and is looking for the right skills to shape it optimally (Mulugetta et al., 2022).

There are fears in many quarters of Nigeria regarding the technical capacity to drive the huge opportunity the renewable energy access sector offers (Berahab, 2022). The fear could be likened to the experience preceding the current state of the oil and gas sector of the country. The oil and gas sector was heavily dominated and operated by foreigners not until recently did Nigerians begin to feature in the sector significantly. In some context, the lack of local capacity in the oil and gas was attributed to systemic barriers intentionally created by foreigners to hedge out Nigerians from the oil and gas operations (Diemuodeke, 2022). Apparently, it took over thirty years before Nigerians started playing a significant role in the oil and gas sector because of a lack of adequate skills and competencies. Now that Nigerians are just beginning to play some significant roles in the oil and gas sector, the energy transition is becoming the pathway to go for sustainability's sake. The fear now is that what happened in the oil and gas energy sector (shortage of local professionals) could be lurking in the renewable energy access sector.

It was, therefore, necessary and imperative to develop a context-sensitive and globally recognized curriculum to drive capacity building around the renewable energy access sector in order to provide local-sensitive innovative energy solutions for socio-economic development (Sokona, 2021). In this context, capacity building is the development of a set of

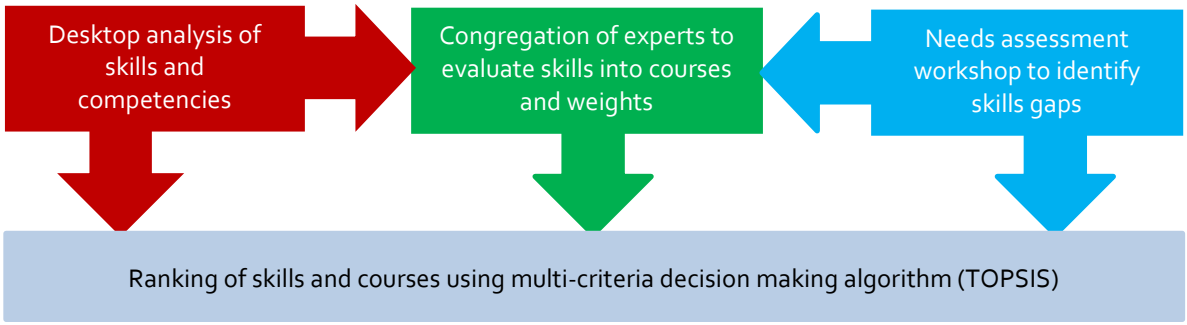
BY-NC-SA 2024, Editorial Universitat Politècnica de València

skills and competencies to effectively provide context-sensitive innovative energy solutions and an impeccable institutional framework to effectively implement and manage the innovations.

2. Methodology

The curriculum development was achieved in three phases; (1) desktop analysis of skills and competencies (2) local needs assessment and (3) congregation of subject experts. Fig. 1 depicts the methodological approach flowchart. The desktop analysis was conducted to identify and evaluate works in the open domain to establish skills and competencies required to drive the energy access sector with renewable energy. The local needs assessment was done by organizing a needs assessment workshop, which convoked local practitioners (including government agencies and academics) in the energy access sector to identify skills and competencies gaps and to align the identified skills and competencies in the first phase with the identified gaps. After this, academic experts were consulted to evaluate the skills into courses and to provide weights for each of the skills. Thereafter, the required skills and competencies were ranked with Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) based on local context and global relevance metrics using surveys and interviews.

Fig. 1 – Methodological approach



Source: Authors

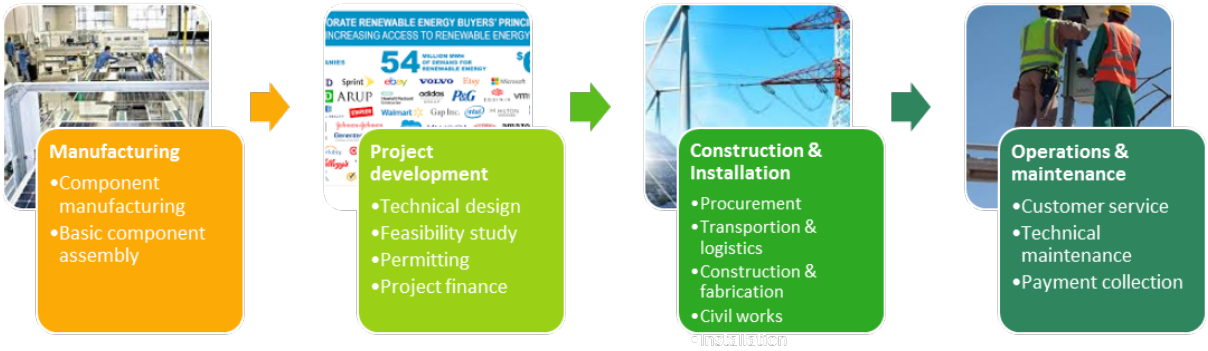
TOPSIS is one of the multi-criteria decision-making (MCDM) algorithms, which has gained traction in many decision-making analysis in engineering and business because it offers some advantages in the form of comprehensibility, simplicity, rationality, computational efficiency and simple mathematics that relate the relative performance of featured alternatives (Diemuodeke, 2019). The final stage of the curriculum development was to fashion the skills and competencies into courses, intended learning outcomes, objectives and delivering methods using subject experts. At the course design stage, Bloom's taxonomy was strictly the building block at the level of a Master's degree (high-level manpower) for teaching and assessment (Chandio et al., 2021).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Results and Discussion

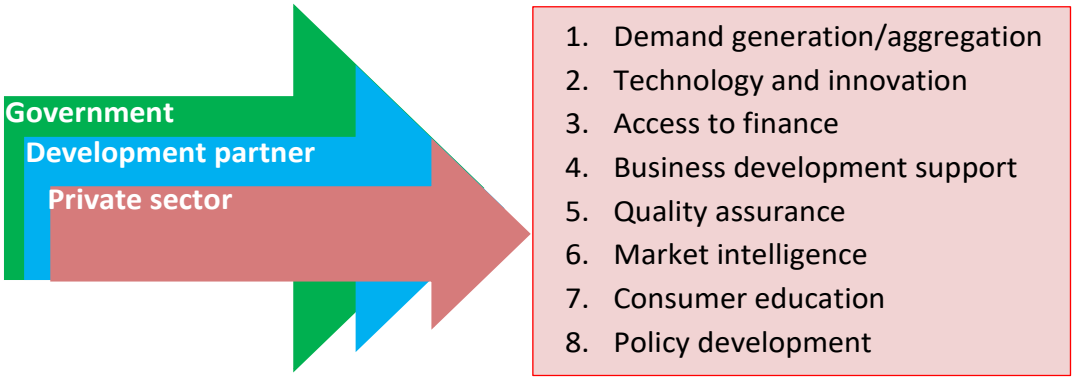
The study shows that multi-disciplinary skilled workforces are strongly needed to navigate the complexity of the identified skills and competencies and there was a need for synergy among governments, development partners and the private sector as shown in Figs 2 and 3.

Fig. 2 – Identified skills and competencies



Source: Authors

Fig. 3 – Areas of synergy and competency demand

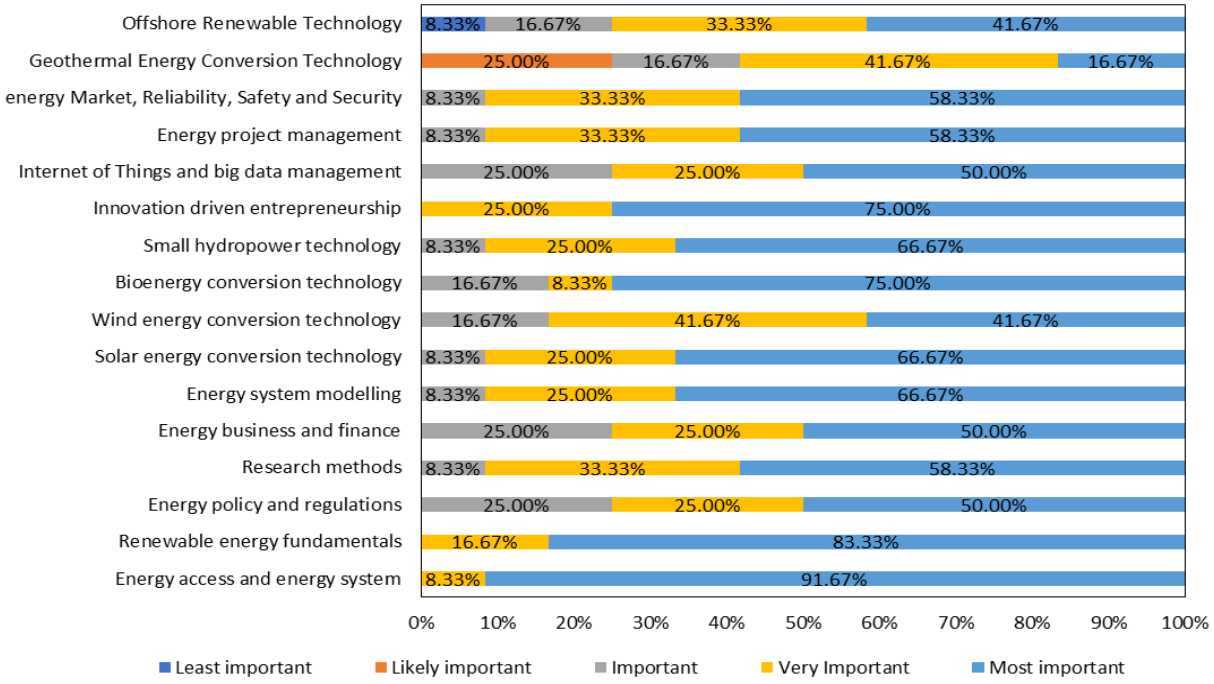


Source: Authors

To deliver the skill sets (hard and soft), the courses were ranked, as presented in Fig. 4, targeting master's degree students. The student-centred and problem-based learning (Zilouchian et al., 2023) methodologies were recommended to deliver the courses to aid students in acquiring the soft skills aspects of the curriculum. The curriculum developed emphasised technical competencies, policy analysis, political economy of rural livelihood, gender mainstreaming, entrepreneurship and commercialisation and environmental sustainability as the pillars driving the teaching and delivery. The courses' delivery provides the students with the opportunity to interact with critical stakeholders (e.g end-users), which allows students to consider the social aspect of energy solutions that benefit all.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 4 – Respondents' preferences for MSc course structure



Source: Authors

The MSc programme aims to develop non-gender-biased high-level energy professionals with competencies and skills to navigate complex challenges in the energy access sector. The objectives of the proposed MSc programme are to deliver the capacity to enhance knowledge of, and expertise in:

(i) The various renewable energy technologies aimed at energy access for household, public and productive uses.

(ii) Appropriate delivery mechanisms, business models and innovative entrepreneurial responses to rural and economic development as well as marketing innovation.

(iii) The social context and consumer environment including gender and energy, understanding consumer preferences and behaviour, consumption and technology adoption patterns.

(iv) Policy, planning, regulatory and legal considerations including energy systems modelling, and policy mechanisms to stimulate innovation and energy access markets.

After reorganisation of the ranked courses, Table 1 was adopted to deliver an MSc programme in Energy Access and Renewable Energy Technology.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Revised programme/course structure

	Course Name	Core/ Elective
1.	Energy access and energy systems	Core
2.	Renewable energy fundamentals	Core
3.	Entrepreneurship and Management	Core
4.	Solar energy conversion technology	Core
5.	Energy systems modelling	Core
6.	Bioenergy conversion technology	Core
7.	Hydropower technology	Core
8.	ICT and Research Methods	Core
9.	Energy policy and regulations	Core
10.	Design project and graduate seminar	Core
11.	Internship	Core
12.	MSc dissertation	Core
13.	Wind energy conversion technology	Elective*
14.	Geothermal energy conversion technology	Elective
15.	Offshore renewable technology	Elective

*Students are required to choose one of the elective courses

Source: Own elaboration

4. Conclusion

Historically, there exist five innovation revolutions, namely water (1st), steam (2nd), coal and electricity (3rd), oil and gas (4th), and digital technology (5th). The current climate crisis and the need to drive the digital revolutions would progress into the sixth innovation revolution, which will be driven by clean energy. However, the energy access sector (anchored on renewable energy) of sub-Saharan Africa (SSA), especially the mini-grid, is very large and is looking for the right skills to shape it optimally.

The paper presents the process used in the development of a context-sensitive curriculum for sustainable energy education to build high-level human capacity at the Master's degree level. The process of the curriculum development includes; (1) desktop analysis of skills and competencies (2) local needs assessment and (3) congregation of subject experts. The curriculum developed emphasised technical competencies, policy analysis, political economy of rural livelihood, gender mainstreaming, entrepreneurship and commercialisation, and environmental sustainability as the pillars driving the delivery. It is hoped that proper implementation and support by critical stakeholders will eliminate the ugly experience of Nigerians in the oil and gas sector during its business evolution - the oil and gas sector was heavily dominated and operated by foreigners not until recently Nigerians began to feature in the sector significantly.

Acknowledgements

The authors acknowledge the UK Government funding (administered by Carbon Trust) for curriculum development under the Transforming Energy Access – Learning Partnership

BY-NC-SA 2024, Editorial Universitat Politècnica de València

(TEA-LP) programme. However, the findings presented in the paper do not necessarily represent the position of the UK Government.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Abbass, K., Qasim, M.Z., Song, H. Murshed, M., Mahmood, H., Younis, I. (2022) A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environ Sci Pollut Res 29, 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Berahab, R. (2022) The Nigerian Energy Crisis: What Prospects for Green Recovery and Transatlantic Integration?, Policy Center for the New South. https://www.policycenter.ma/sites/default/files/2022-02/paper-rb.pdf. Retrieved: 22 March 2023.

Chandio, M.T., Zafar, N., Solangi, M. (2021) Bloom's Taxonomy: Reforming Pedagogy Through Assessment, Journal of Education and Educational Development, Vol. 8(1), 109-140. http://dx.doi.org/10.22555/joeed.v8i1.308

Diemuodeke, E.O. (2022) Re-imaging energy Nigeria's structures by 2030 https://www.acu.ac.uk/publications/case-studies/commonwealth-futures-climate-research-cohort-case-studies/2021-pilot-programme/collaborating-for-humanitys-future/ogheneruona-diemuodeke/

Diemuodeke, E.O., Addob, A., Oko, C.O.C., Mulugetta, Y., Ojapah, M.M. (2019) Optimal mapping of hybrid renewable energy systems for locations using multi-criteria decision-making algorithm, Renewable Energy, 134, 461-477. https://doi.org/10.1016/j.renene.2018.11.055

Mulugetta et al. (2022) Africa needs context-relevant evidence to shape its clean energy future, Nature Energy. https://doi.org/10.1038/s41560-022-01152-0

Newman, P. (2020) COVID, CITIES and CLIMATE: Historical Precedents and Potential Transitions for the New Economy, Urban Sci. 2020, 4, 32; https://doi.org/10.3390/urbansci4030032

Sokona, Y (2021) Building capacity for 'energy for development' in Africa: four decades and counting, Climate Policy. https://doi.org/10.1080/14693062.2020.1870915

Solarin, S.A., Bello, M.O., Tiwari, A.K. (2022) The impact of technological innovation on renewable energy production: accounting for the roles of economic and environmental factors using a method of moments quantile regression, Heliyon, 8, e09913. https://doi.org/10.1016/j.heliyon.2022.e09913

Zilouchian, A., Abtahi, A., Romance, N. (2023) Curriculum Development in Renewable Energy and Sustainability, Annual Conference and exposition, Baltmire, June 25-28, 2023.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Energy poverty training awareness in vocational and technical education

Sofia-Natalia Boemi[a], Stavros Spyridakos[a] , Stefania Zourka [a], Evridiki Mantela [b], Stefanos Dodouras [b], Nikolaos Ntavos [a,b] and Ioannis Fallas [a,b]

[a] Energy and Climate Action Department, Cluster of Bioeconomy and Environment of Western Macedonia, Greece

[b] Department of Sustainable and Intelliigent Transition, Cluster of Bioeconomy and Environment of Western Macedonia, Greece

Abstract

Energy poverty has been identified as a major contributor to social inequality and health that could be alleviated mainly through energy efficiency measures. Fuel costs, low incomes, and energy-inefficient housing facilities are the key constituents of energy poverty, affect the mortality rate, and create educational inequalities.

Energy poverty also poses a significant challenge to sustainable global development. The complex but desirable role of education and financial flow is a prerequisite for facilitating technological innovations, especially with the rapid advancement of information technology; understanding its role in alleviating energy poverty holds great practical significance.

In that framework, this paper discussed the role of upgrading or altering skills for technician energy poverty illiteracy and technological innovation. The aim is to record the essential skills that should be qualified to tackle energy poverty via vocational training. The conclusions of this paper provide valuable insights into leveraging information on the lack of energy education programs to alleviate energy poverty.

Keywords: energy poverty; green skills; energy skills; sustainable education.

How to cite: Boemi, S.N.; Spyridakos, S.; Zourka, S.; Mantela, E.; Dodouras, S.; Ntavos, N. and Fallas, L. (2024) Energy poverty training awareness in vocational and technical education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 153-160. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The concept of energy poverty originated from the British term "fuel poverty", which meant insufficient energy for impairing people's living standards Lewis (1982). The context was extended by Boardman (1991) as the inability to afford adequate warmth because of the inefficiency of energy. Subsequently, the definition of energy poverty has been continuously supplemented or altered until recently, when the European Commission provided a holistic definition in the revision of the Energy Efficiency Directive. According to that, "*energy poverty means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes*".

In existing literature, energy poverty is usually considered from two dimensions: energy accessibility and energy affordability. The former is the access to stable and secure energy, reflecting the completeness of energy systems and energy infrastructure. Affordability refers to the ability to pay energy bills related to energy prices, consumption habits, and family disposable income. Thus, energy poverty is affected by many factors, and its estimation needs to be comprehensively considered. The measurement method will affect the calculated proportion of people in energy poverty and the formulation of policies. Hence, measuring energy poverty has always been one of the focuses of academic discussions (Villalobos et al., 2021).

There have been studies on energy poverty in many countries and regions, including the European Union (Zalostiba and Kiselovs, 2021), Poland (Karpinska and Smiech, 2021), Uganda (Ssennono et al., 2021), Spain (Barrella et al., 2021), China (Dong et al., 2021). The characteristics and causes of energy poverty vary. However, there is a consensus that the long-term existence and worsening of energy poverty will seriously hinder the sustainable development of society.

The direct impact of energy poverty is inhibiting economic development. Households with low income have to spend a large proportion of their income on energy, which is mainly inefficient and polluting energy. In addition to economic support, the completeness and optimization of energy systems are also important for alleviating energy poverty. Wang et al. (2017) believed that the combination of large-scale renewable energy base and small-scale distributed energy can inhibit energy poverty in China. Dong et al. (2021b) found a significant bidirectional causal relationship between low-carbon energy transition and alleviating energy poverty, especially in areas with serious energy poverty. Xia et al. (2022) found that

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

the decentralization of financial power and the increase of national risk will aggravate energy poverty.

The existing studies on the education-energy poverty nexus though limited in number, unravel a negative and statistically significant direct channel between educational attainment and energy poverty (Apergis et al., 2022; Boemi et al., 2017). Even though there is a clear link between energy poverty and education, especially in low-income countries, the literature contribution to the topic remains premature, especially when considering vocational training activities. Moreover, improvements in energy-efficient buildings and access to clean energy enhance the reduction of educational costs, such as heating and cooling, providing more students the opportunity to continue studying (Karekezi, 2012).

Education's role in economic growth has been widely discussed as well as the effectiveness of education in reducing poverty (Sun et al., 2023). However, poverty is multidimensional, and more recently introduced energy poverty has received little attention, specifically its interactions with education. Studies that report the relationship between education and energy poverty have been segregated based on two principles. The first has reflected energy poverty as a significant indicator of education and the second is the research stream that highlights education's impact on energy poverty reduction.

The study by Banerjee et al. (2021) pointed out that lower energy poverty is associated with higher education and health status. Similarly, using the household income and expenditure data, Omar and Hasanujzaman (2021) estimated the multidimensional poverty index for Bangladesh. It stated that energy poverty harms health and education simultaneously. In a similar study exploring the role of energy poverty on education inequality. Katoch et al. (2023) reviewed 22 published articles on the impact of energy poverty and education and disclosed the negative effect of energy poverty on education and health. A survey-based study disclosed that energy poverty was prevalent in rural households with lower incomes; thus, this ultimately negatively impacted households'health and education levels in Lao PDR (Sun et., 2023). Along similar lines,Jayasinghe et al. (2021) coined that health and education are deteriorating with increasing energy poverty in Sri Lanka.

Boemi et al.(2017) reported that higher educational level of residents are connected with better living conditions and the most energy-efficient housing facilities. A recent study is from Apergis et al. (2022), who analyzed the data from 30 countries and stated that education might reduce energy poverty over time. Similarly, Niu et al. (2023) diagnosed that in countries with high energy poverty, the improvement in education level is a positive indicator of public health; therefore, they recommended developing education to eradicate energy poverty in respective countries.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

From the above-discussed literature, the studies performed in the past have concentrated on the response of energy poverty to education. However, these studies often provide limited information or fail to establish a consensus due to methodological weaknesses, data availability issues, or the indicators employed. Therefore, a rigorous analysis of this topic is essential. In that framework, this paper aims to investigate the link between education and energy poverty and thus bridge the gap in the current literature. The main motivation is to discuss the mechanism by which education impacts energy poverty and which are the essential skills, lending from a theoretical background, that are needed to mitigate energy poverty

2. Study methodology

The work discussed in this article was conducted as part of the post-doctoral study, financed by the Greek State Scholarships Foundation (IKY) and continued via the technical assistance of the Energy Poverty Advisory Hub of the European Commission. This project aims to foster the development of Vocational Education and Training (VET) Excellence in Energy Poverty across European municipalities. That is an ongoing EU study that started in September 2014 and is ongoing until today.

The architectural artifacts of this study were derived following a systematic research survey. All the necessary information was collected following a systematic research survey method. In that direction, to comprehensively investigate the relationship between education and energy poverty, a systematic literature review was conducted. This review targeted peer-reviewed journal articles from the last five years. The search employed keywords including "education", "energy poverty", "energy accessibility", and "energy affordability". Articles were selected based on predefined inclusion criteria, focusing on their relevance to the research question and provision of empirical evidence or theoretical insights. Data extraction encompassed study characteristics, population demographics, key findings, and methodological approaches. Quality assessment criteria were applied to evaluate the clarity of research objectives, appropriateness of methodology, rigor of data analysis, and transparency of reporting. Synthesis involved summarising key findings, identifying common themes, and addressing gaps in the literature.

3. Result analysis

Investment in training education and skills is essential to boost growth and competitiveness. Skills development, according to CEDEFOP (2023), will determine Europe's capacity to increase productivity. In the long term, skills can trigger innovation and growth, stimulate the concentration of higher-level skills at the EU level, and shape the future labour market.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Vocational training is a big tool for solving any country's economic, political, and social crises that threaten economic stability and the political environment, as well as poverty issues (Hayyat and Chughtai, 2015). Hence, vocational training is important in providing employment opportunities to individuals and helping improve organisations' productivity. Likewise, vocational training is an indispensable instrument for improving labour mobility, adaptability, and productivity, thus improving the organisations' competitiveness and redressing labour market imbalances (EP, 2023).

Energy poverty is critical to the economies' labour force, economic growth, and social well-being (Oldfield, 2011). Therefore, economies have started taking various measures to respond to and tackle climate change effectively. With the Green Deal, the EU set the first step to Greening the EU economy. The greening goes hand in hand with technological development and innovation. A transition to renewables does not merely represent the development of energy generation technology. Instead, it marks the emergence of new approaches to energy production, consumption and efficiency, together with similarly novel skill requirements.

In that direction, occupations driving innovation, such as engineers, specifically renewable energy engineers, can trigger innovation and 'green' solutions and demand high skills. Digitalisation, the other half of the twin transition, is a key driver of skill and job change. Significant growth is expected in ICT-related occupations, boosting the green transition (CEDEFOP, 2023). Those occupations may be small in terms of employment shares, but they are indispensable in making the green transition happen. New-generation occupations and innovation in new technologies are considered effective in providing knowledge and measures for the eradication of energy poverty.

However, to create the essential skills for energy poverty eradication, current professionals need to extend their expertise to bridge the skill gap. Similarly, the education and training of new professionals must adapt to the new requirements. Skills such as Energy Efficiency/conservation, project development and management, problem-solving, Energy Policies/Regulations, and Environmental Impact Assessment are needed.

Unfortunately, this has proven to be difficult. Lucas et al. (2018) report that too few engineering schools have adapted, partly due to the time it takes for curricula to change or for course materials to be absent. Even if traditional engineering courses incorporate modules on sustainability and renewable energies, these may need more detail (Jennings, 2009), especially since they should be combined with social studies. Fully specialised degrees could produce the competencies demanded but may represent all-too-fleeting niches (Lucas et al., 2018).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Conclusions

With the surge in human resource consumption, the energy issue is becoming increasingly serious and complex. This paper explores the potential alleviating effect of the new skill sets for eradicating energy poverty.

Using new technologies and changing curricula in engineering departments, including more social courses, can effectively assist in that direction and alleviate energy poverty. Moreover, the impact of modern telecommunications, internet, and database technologies, which can integrate social resources, improve social production efficiency, and improve social welfare, becomes stronger as energy poverty worsens. In practice, some questions need to be answered about smoothing the development profile that will now affect even future aspects of energy poverty.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Apergis,N., Polemis,M., Soursou, S.E., Karekezi, S.M., (2022). Energy poverty and education: Fresh evidence from a panel of developing countries. *Energy Economics*, 106, 105430. https://doi.org/10.1016/j.eneco.2021.105430

Banerjee, R., Mishra,V., Maruta, A.A., (2021). Energy poverty, health and education outcomes: evidence from the developing world. *Energy Economics*, 101, 105447. https://doi.org/10.1016/j.eneco.2021.105447

Barrella, R., Linares, J.I., Romero, J.C., Arenas, A., Centeno, E., (2021). Does cash money solve energy poverty? Assessing the impact of household heating allowances in Spain. *Energy Research and Social Science*, 80, 102216. https://doi.org/10.1016/j.erss.2021.102216.

Boardman, B., (1991). Fuel Poverty: From Cold Homes to Affordable Warmth. *Pinter Pub Limited*

Boemi, A.N., Avdimiotis, S., Papadopoulos, A.M., (2017). Domestic energy deprivation in Greece: a field study. *Energy and Buildings*, 144, 167-174. https://doi.org/10.1016/j.enbuild.2017.03.009

Cedefop, (2023). From 'greenovators' to 'green' minds: key occupations for the green transition: the nuances of defining 'green' occupations. *Publications Office of the European Union*. https://data.europa.eu/doi/10.2801/87959

2024, Editorial Universitat Politècnica de València BY-NC-SA

Dong, K.Y., Jiang, Q.Z., Shahbaz, M., Zhao, J., (2021). Does low-carbon energy transition mitigate energy poverty? The case of natural gas for China. *Energy Economics*,99, 105324. https://doi.org/10.1016/j.eneco.2021.105324

Dong, K.Y., Ren, X.H., Zhao, J., (2021). How does low-carbon energy transition alleviate energy poverty in China? A nonparametric panel causality analysis. *Energy Economics*, 103, 105620. https://doi.org/10.1016/j.eneco.2021.105620

European Parliament, 2023. MOTION FOR A EUROPEAN PARLIAMENT RESOLUTION on fostering and adapting vocational training as a tool for employees' success and a building block for the EU economy in the new industry 4.0, European Parliament - Committee on Employment and Social Affairs

Hayat, A.A., Kohoulat, N., Kojuri, J., Faraji, H., (2015). A Study on the Relationship Between Schools' Health and Teachers' Organizational Commitment. International_Journal of School Health, 2(4). https://doi.org/ 10.17795/intjsh26099

Jayasinghe, M., Selvanathan, E.A.,Selvanathan, S., (2021). Energy poverty in Sri Lanka. *Energy Economics*, 101, 105450. https://doi.org/10.1016/j.eneco.2021.105450

Jennings, P., (2009). New directions in renewable energy education. Renewable Energy, 34, 435-439. https://doi.org/10.1016/j.renene.2008.05.005

Karekezi. S, McDade, S., Boardman, B., Kimani, J., Lustig, N., (2012). Global Energy Assessment Writing Team. Energy, Poverty, and Development. In: Global Energy Assessment: Toward a Sustainable Future. Cambridge University Press, 151-190. https://doi.org/10.1017/CBO9780511793677

Karpinska, L., Smiech, S., (2021). Breaking the cycle of energy poverty. Will Poland make it? *Energy Economics 94*, 105063. https://doi.org/10.1016/j.eneco.2020.105063

Katoch, O.R., Sharma, R., Parihar, S., Nawaz, A., (2023). Energy poverty and its impacts on health and education: a systematic review. International Journal of Energy Sector Management, 18 (2), 411-431. https://doi.org/10.1108/IJESM-10-2022-0007

Lewis, P., (1982). Fuel Poverty Can Be Stopped. *National Right to Fuel Campaign*

Lucas, H., Pinnington, S., Cabeza, L.F., (2018). Education and training gaps in the renewable energy sector. Solar Energy,173, 449-455. https://doi.org/10.1016/j.solener.2018.07.061

Niu,S., Chen, Y., Zhang, R., Luo, R., Feng, Y., (2023). Identifying and assessing the global causality among energy poverty, educational development, and public health from a novel perspective of natural resource policy optimization. *Resources Policy*, 83, 103770. https://doi.org/10.1016/j.resourpol.2023.103770

Nsenkyire, E., Nunoo,J., Sebu, J., Iledare, O., (2023). Household multidimensional energy poverty: impact on health, education, and cognitive skills of children in Ghana. *Child Indicators Research*, 16, 293-315. https://doi.org/10.1007/s12187-022-09970-0

Oldfield, E., (2011). Addressing Energy Poverty through Smarter Technology. *Bulletin of Science, Technology & Society*, *31*(2), 113-122. https://doi.org/10.1177/0270467610391291

Omar, M.A., Hasanujzaman, M., (2021). Multidimensional energy poverty in Bangladesh and its effect on health and education: a multilevel analysis based on household survey data. *Energy Policy*, 158, 112579. https://doi.org/10.1016/j.enpol.2021.112579

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Oum, S., (2019). Energy poverty in the Lao PDR and its impacts on education and health. *Energy Policy*, 132, 247-253. https://doi.org/10.1016/j.enpol.2019.05.030

Ssennono, V.F., Ntayi, J.M., Buyinza,F., Wasswa, F., Aarakit, S.M., Mukiza, C.N., (2021). Energy poverty in Uganda: evidence from a multidimensional approach. *Energy Economics*, 101, 105445. https://doi.org/10.1016/j.eneco.2021.105445

Sule, I.K., Yusuf, A.M., Salihu, M-K., (2022). Impact of energy poverty on education inequality and infant mortality in some selected African countries. *Energy Nexus*, 5, 100034. https://doi.org/10.1016/j.nexus.2021.100034

Sun, C., Khan, A., Ren, Y., (2023). Empowering Progress: Education, innovations and financial development in the battle against energy poverty. *Journal of Cleaner Production*, 425, 138941. https://doi.org/10.1016/j.jclepro.2023.138941

Tewathia, N., (2014). Determinants of the household electricity consumption: a case study of Delhi. *International Journal of Energy Economics and Policy*, 4 (3), 337-348

Villalobos, C., Chavez, C., Uribe, A., 2021. Energy poverty measures and the identification of the energy poor: a comparison between the utilitarian and capability-based approaches in Chile. *Energy Policy*,152, 112146. https://doi.org/10.1016/j.enpol.2021.112146

Wang,B., Li, H.N., Yuan, X.C., Sun, Z.M., (2017). Energy poverty in China: a dynamic analysis based on a hybrid panel data decision model. *Energies*,10, 1942. https://doi.org/10.3390/en10121942

Xia, W.J., Murshed,M., Khan, Z., Chen, Z., Ferraz, D., (2022). Exploring the nexus between fiscal decentralization and energy poverty for China: does country risk matter for energy poverty reduction? *Energy*, 255, 124541. https://doi.org/10.1016/j.energy.2022.124541

Zalostiba, D., Kiselovs D., (2021). A review: the energy poverty issue in the European Union and Latvia. *Latvian Journal of Physics and Technical Sciences 52 (3),* 227-248. https://doi.org/10.2478/lpts-2021-0028

Zhao, X., (2022). Research on management informatization construction of electric power enterprise based on big data technology. *Energy Reports*, 8 (7), 535-545. https://doi.org/10.1016/j.egyr.2022.05.124

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Challenge-Based Control Education In A Master Module Of Renewable Energy Systems

Georg Pangalos[a], Carlos Cateriano Yáñez[a,b,c], Timon Kampschulte[c] and Gerwald Lichtenberg[c]

[a]Application Center for Integration of Local Energy Systems, Fraunhofer Institute for Wind Energy Systems IWES, Germany

[b]Universitat Politècnica de València, Instituto Universitario de Automática e Informática Industrial, Spain

[c]Hamburg University of Applied Sciences, Faculty Life Sciences, Germany

Abstract

This paper introduces a challenge-based control engineering module in a master program of renewable energy systems. Previous work has already established challenge-based learning for control education through the so-called "Control Challenge" examination format. This work seeks to reach the student learning outcomes by introducing a multi-criteria decision-making problem, which is closer to a real-world scenario. This is achieved by establishing a multi-objective control challenge with no weighting factors for each objective. This subtle change places the students in an uncommon situation where there is no unique correct answer. The students work through the control challenge in groups, developing a software solution to test their practical skills and a poster presentation to test their theoretical knowledge. Finally, the student solutions are compared via Pareto dominance, which leads to a Pareto front comprised of multiple Pareto optimal solutions. By allowing multiple correct solutions, the Pareto front serves as a medium for portraying the decision-making trade-offs of real-world applications. In these situations, different solutions for the same engineering problem are possible based on a decision-maker's priorities.

Keywords: control education; challenge-based learning; multi-criteria decision making; master modules.

How to cite: Pangalos, G.; Cateriano Yáñez, C.; Kampschulte, T. and Lichtenberg, G. (2024) Challenge-based control education in a master module of renewable energy systems. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 161-168. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

To motivate the inclusion of control engineering courses in sustainable energy education, recall that today, providing renewable energy is more important than ever to reduce greenhouse gas emissions and mitigate climate change. This is why many countries have set up programs to transform their power supply into a sustainable one and reach their climate goals. On the other hand, this transformation process implies a huge investment into infrastructure like wind farms, solar power plants, smart grids, and low-emission heating systems, as well. After initial steps into renewable energy systems from the 1980s to the 2000s, when demonstrating feasibility was important, today, the focus is more and more on efficiency and the levelized costs of energy (LCoE) of those systems. This is where control system engineering as a cross-over discipline plays a more significant role, particularly in the optimization and efficient operation of renewable energy systems. Thus, in the academic education of engineering students in renewable energy systems, courses on control systems are a fundamental element of the study programs and training on an interdisciplinary approach to engineering problems. As control engineering is sometimes said to be very theoretical, modern didactical concepts can significantly raise the motivation of students and, by this, also improve the learning outcome.

Challenge-based education is an emerging field and an extension of the well-known concept of problem-based learning. The extension is to not only let the students find a solution to a real-world problem but in addition let the students compete for the best solution to this problem. In 2020, the European Consortium of Innovative Universities (ECIU) started an EU-funded initiative, i.e., the ECIU university, to place the challenge-based approach as a core for its pedagogics (*ECIU University About Why & How*, 2024). With this, the ECIU is following its affiliated partner Tecnológico de Monterrey in Mexico, who already introduced the concept in 2008. Challenge-based education in control engineering already dates back to 2006, when the concept was used in a "Fundamentals in Control Engineering" course at Hamburg University of Technology as described in Lichtenberg and Kwiatkowski (2006).

The idea of posing a control challenge to the students was adopted to an advanced control systems module in a renewable energy systems master's program at the Hamburg University of Applied Sciences in the Faculty of Life Sciences. In this module, a portfolio examination is used to assess the student's competencies. The matching of the taxonomy levels, ranging from "knowledge", "understanding", "application", and "diagnosis" to "synthesis", and "transfer" to different forms of the examination was described in Lichtenberg and Pangalos (2022). In this contribution the focus is on the challenge-based education, which here is realized by means of the control challenge. In contrast to the approach in Lichtenberg and Kwiatkowski (2006) the challenge in this module is set in the context of renewable energy systems and sustainability with a multi-objective approach.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The paper is organized as follows. The next section gives an overview of the master's program in which the advanced control systems module is embedded, followed by a description of the advanced control systems module in Section 3, focusing on the examination procedure. Section 4 gives an example of a control challenge, and Section 5 discusses the extended abstract.

2. Master's program "Renewable energy systems – Environmental and Process Engineering (M.Sc.)"

The master's program "Renewable Energy Systems – Environmental and Process Engineering (Master of Science)," in short MSc RES, was established in 2009 and has since been revised several times. It is a joint program of the departments of Environmental Engineering and Process Engineering at the Faculty of Life Sciences at Hamburg University of Applied Sciences, strongly cooperating with research institutions like the university's Competence Centre for Renewable Energies and Energy Efficiency (CC_4E) or the Fraunhofer Institute for Wind Energy Systems (IWES) and others.

This master's degree course comprises advanced modules in the technology and engineering of renewable energy systems like bioenergy, solar energy, wind energy systems, and downstream systems for energy transformation, distribution, and storage. The course's main emphasis is on systems engineering for a sustainable and environmentally friendly energy supply, accompanied by the acquisition of in-depth knowledge of mathematical and IT skills, process simulation techniques, advanced electrical engineering, and advanced control systems. The training of key skills is provided by the imparting of knowledge on project financing, international energy policy, project management, and project economic evaluation in specialized courses. All course content features an applied approach. In addition to lectures, project and lab work is an essential aspect of the program. Students can get involved in local and international collaborations run by the Faculty of Life Sciences.

The MSc RES is an international 1 ½ years program, corresponding to 90 credit points according to the European Credit Transfer and Accumulation System (ECTS), and is taught in English. It is structured into three semesters, whereas in the first two semesters, students attend lectures, seminars, labs, and project work; in the third semester, the master's thesis of 6 months duration takes place. The master's thesis can be done internally, i.e., in university's research groups or institutes, in external research institutions, or in companies. A company-based master's thesis is the option most students choose, which accentuates the concept of a university of applied sciences, where research and development activities are strongly related to the current needs in industry and business. As an outcome, after finishing the master's program, students are often offered an entry-level position in the company they have worked with for their thesis.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Module "advanced control systems"

The module advanced control systems is divided into two parts. One part being a 90-minute theory lecture, and the other part being a 90-minute computer lab; both taught over the duration of one semester (13 weeks), and both are credited with 2.5 credit points. The module is subject to the established evaluation of the education by the students at the HAW Hamburg. Recommended prerequisites for the module are linear algebra, calculus, basic informatics, systems theory, and control basics. The learning outcomes of the module are that the students

- design advanced controllers
- using appropriate numerical tools
- by methods based on state-space models
- which they identify from data or first principles
- to improve the closed-loop performance or robustness
- of complex systems like renewable energy systems.

The lecture aims to give a theoretical background on the topics of systems and control, whereas the practice part focuses on employing the theoretical concepts to model and design tasks in Matlab/Simulink. There are five parts to the portfolio examination of the module. In the first half of the semester, there are two modeling tasks in the practice part and a written multiple-choice midterm exam in the theory part. The second half of the semester is concluded with the control challenge, which is graded in the practice part on the basis of a software review and in the theory part on the basis of a poster presentation. The software review checks best practices in using the software Matlab/Simulink, and the poster presentation checks the theoretical approaches of the challenge solutions.

4. Control challenge

The control challenge is a controller design task, which the students can solve over the duration of several weeks. The task is to be solved using a model-based controller design method. The model can either be used to tune the controller or as part of the controller itself. Since model predictive control is one of the concepts taught in the course, it is a common student's choice, but depending on the task also, e.g., repetitive controllers, have also been designed.

Control challenge topics ranged from heating systems, converter control, active power filters to electrolyzer control but are not limited to these topics. The control challenges are touching our research topics, so for example the control challenge in the summer semester was motivated by the increase of converter-based generation and the power quality issues this can introduce in the power system. To enable the energy transition towards a sustainable

2024, Editorial Universitat Politècnica de València BY-NC-SA

energy system, active power filters (APF) can play an important role. Therefore, the control challenge was:

Find a controller for the APF, which

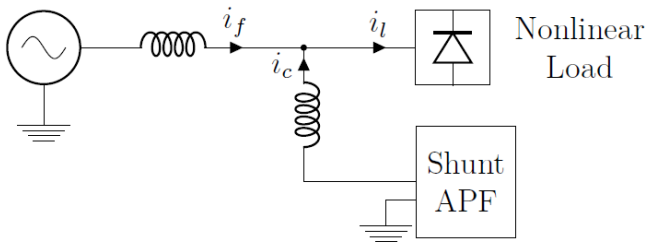
reduces the total harmonic distortion (THD)

and uses minimal power.

The models of the grid, the load, and the APF were given to the students as a Simulink file. The goal of the controller was to find a current i_{co} of the APF such that the total harmonic distortion of the current of line i_f and the absolute value of the active power were minimized. The evaluation was done over the duration of 1 second.

The scheme of the grid, the load, and the APF is given in Fig. 1.

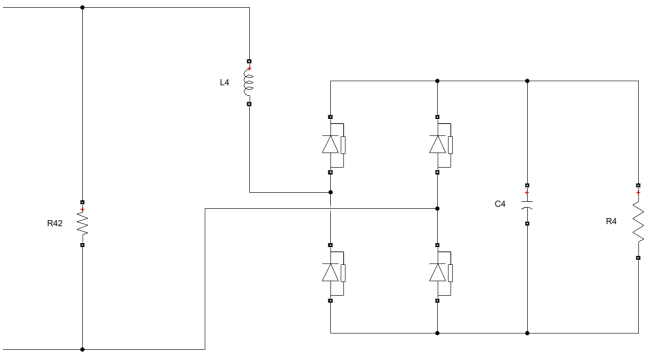
Fig. 1 – Scheme of the grid, the load, and the *APF*



Source: Own elaboration

The scheme of the nonlinear load is given in Fig. 2.

Fig. 2 – Scheme of the nonlinear load

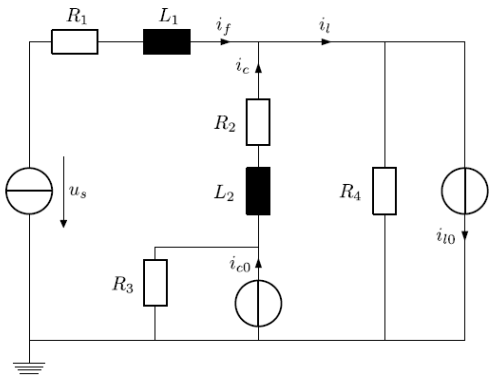


Source: Own elaboration

The equivalent circuit of the grid, the load, and the APF is given in Fig. 3.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 3 – Equivalent circuit of the grid, the load, and the *APF*



Source: Own elaboration

The parameters of the equivalent circuit are given in Table 1.

Table 1 – Parameters of the equivalent circuit

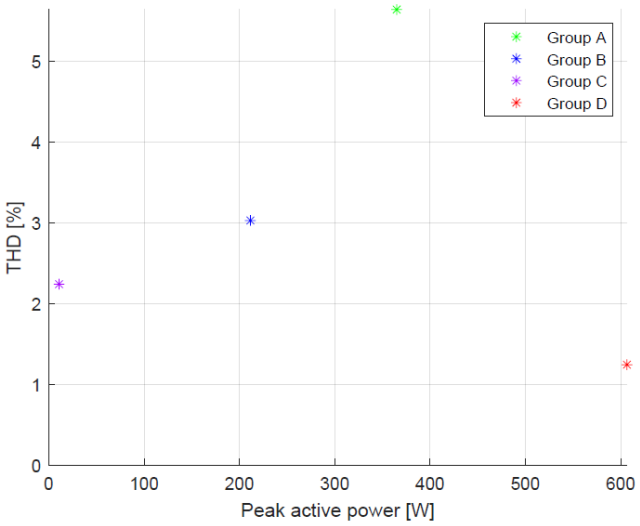
R1	R2	R3	R4	L1	L2
1 Ω	50 mΩ	500 Ω	500 Ω	50 mH	500 mH

Source: Own elaboration

The disturbances for the current of the nonlinear load i_{l0} and the voltage of the grid u_s were given within the model.

The solutions for the task ranged from using model predictive control and repetitive control to state feedback control. The results the groups achieved are given in Fig. 4.

Fig. 4 - Challenge 2021 results



Source: Own elaboration

BY-NC-SA

As the task was to minimize two objectives at the same time, the task has multiple solutions, which are the Pareto optimal solutions. In the four groups of the summer semester 2021, group C found a solution that was better in both objectives than the solutions of groups A and B. Group D found a solution that was better in one objective (THD) but worse in the other objective (Peak active power) than the solution of group C. Without weighing the objectives, it is impossible to judge which solution is better; thus, the control challenge of 2021 was won by the two groups, C and D.

The optimization of the controller for two criteria enabled a discussion of multicriterial optimization during the results presentation. This adds an additional learning outcome compared to the list given above.

5. Conclusion

This work describes a challenge-based control engineering module for a renewable energy systems master program. The challenge-based learning strategy is executed with a control challenge examination format.

Given the strong focus on the practical aspects of renewable energy systems of the master program, being part of an applied science university, a new control challenge approach was formulated to emphasize this in the module. To resemble a more realistic engineering problem, e.g., renewable energy systems, the control challenge was redesigned into an electric microgrid containing multiple objectives with no weighing factor. This change allowed for multiple answers from students depending on their controller choice and tuning.

Each student group solution was compared using the Pareto dominance criteria, leading to a Pareto front containing all the Pareto optimal solutions. Since all the group solutions contained in the Parent front are equally "correct," the students are placed in an unfamiliar situation where there is more than one answer, as shown for groups C and D.

This kind of setup resembles a real-world engineering application common in renewable energy systems with multiple decision criteria. Here, the students play the engineer role, which does not force a single solution but rather guides a decision-maker based on its priorities through the different trade-offs.

The feedback from the students about this module that was offered numerous times is that the solution of the challenge was requirering the building blocks taught during the course and that it was satisfactory to be able to apply the learned techniques to a realistic problem.

Acknowledgements

This work was partly funded with the project Northern German Living Lab (Norddeutsches Reallabor, NRL) by the German Federal Ministry for Economic Affairs and Climate Action.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

ECIU University About Why & How. (2024, February 1). https://engage.eciu.eu/about-why-how

Lichtenberg, G., & Kwiatkowski, A. (2006). TEACHING TOOL BASED CONTROLLER DESIGN – THE CONTROL CHALLENGE. *IFAC Proceedings Volumes*, *39*(6), 235–240. https://doi.org/10.3182/20060621-3-ES-2905.00042

Lichtenberg, G., & Pangalos, G. (2022). Constructive Alignment by Portfolio Exams for an Advanced Control Master Module. *IFAC-PapersOnLine*, *55*(17), 194–199. https://doi.org/10.1016/j.ifacol.2022.09.278

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Development of Practical Research-Led Teaching Activities Using a Low Carbon Heating and Storage System

Dr Robert J Barthorpe

Department of Mechanical Engineering, The University of Sheffield, United Kingdom

Abstract

An identified challenge in sustainable energy education is in enabling students to gain hands on, practical experience with emerging low carbon technologies; and to make connections between their theoretical work (whether core engineering mathematics or through early undergraduate engineering modules) and applications in the energy field. One means of overcoming this challenge is to build teaching activities around the practical research being conducted within academic institutions. This paper presents initial development of a set of research-led teaching activities that make use of a heating and cooling rig initially designed for energy research purposes. The experimental system itself is intended to replicate core elements of a decarbonized domestic heating system, featuring a heat pump, hot water tank, and both controlled draw of domestic hot water and an emitter set up to replicate space heating demand. In addition to this base setup, the system allows connection of alternative heat sources and novel thermal energy storage devices including those based on phase change and thermochemical materials, alongside control hardware and software to enable multiple modes of operation and synchronous monitoring of key system parameters. As an extension to its research purpose, this test bed offers the potential for use within a range of teaching activities within an engineering curriculum. This paper describes the rig itself; presents a brief survey of how similar research rigs have been used for energy education in order to identify best practice in this area; and concludes with possibilities for how to proceed within our own curriculum.

Keywords: Research-Led Teaching; Energy Storage; Decarbonisation of Heat; Efficient Use of Research Assets.

How to cite: Barthorpe, R. J. (2024) Development of Practical Research-Led Teaching Activities Using a Low Carbon Heating and Storage System. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 169-175. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

This paper focuses on how experimental systems developed for research purposes may be used to further energy education within an engineering curriculum. In addition to building knowledge of the underpinning theory and technologies involved, it is foreseen that such research-led teaching has the potential to improve student awareness of both the business as usual (BAU) and future research and development pathways for low carbon technologies. These are important as they are part of the United Nations Sustainabile Development Goals (SDGs), notably 7: Affordable and Clean Energy and 11: Sustainable Cities and Communities (United Nations (n.d.)). Additionally, it provides a means of addressing skills gaps identified by employers in the low carbon energy sector. Hands on experience with real domestic energy systems presents an opportunity for students to consider factors beyond the purely technical, for example user acceptance.

This paper considers on an experimental system designed to allow dwelling level testing of novel thermal storage devices as part of an ongoing research and development project. The work presented is preliminary in nature – the system itself is undergoing commissioning at the time of writing and is part of an active research project – but the best practice identified around delivering research-focused practical teaching at scale using limited rig resources is likely to be of value to educators in the field of energy education.

2. Low Carbon Heating Rig: System Description

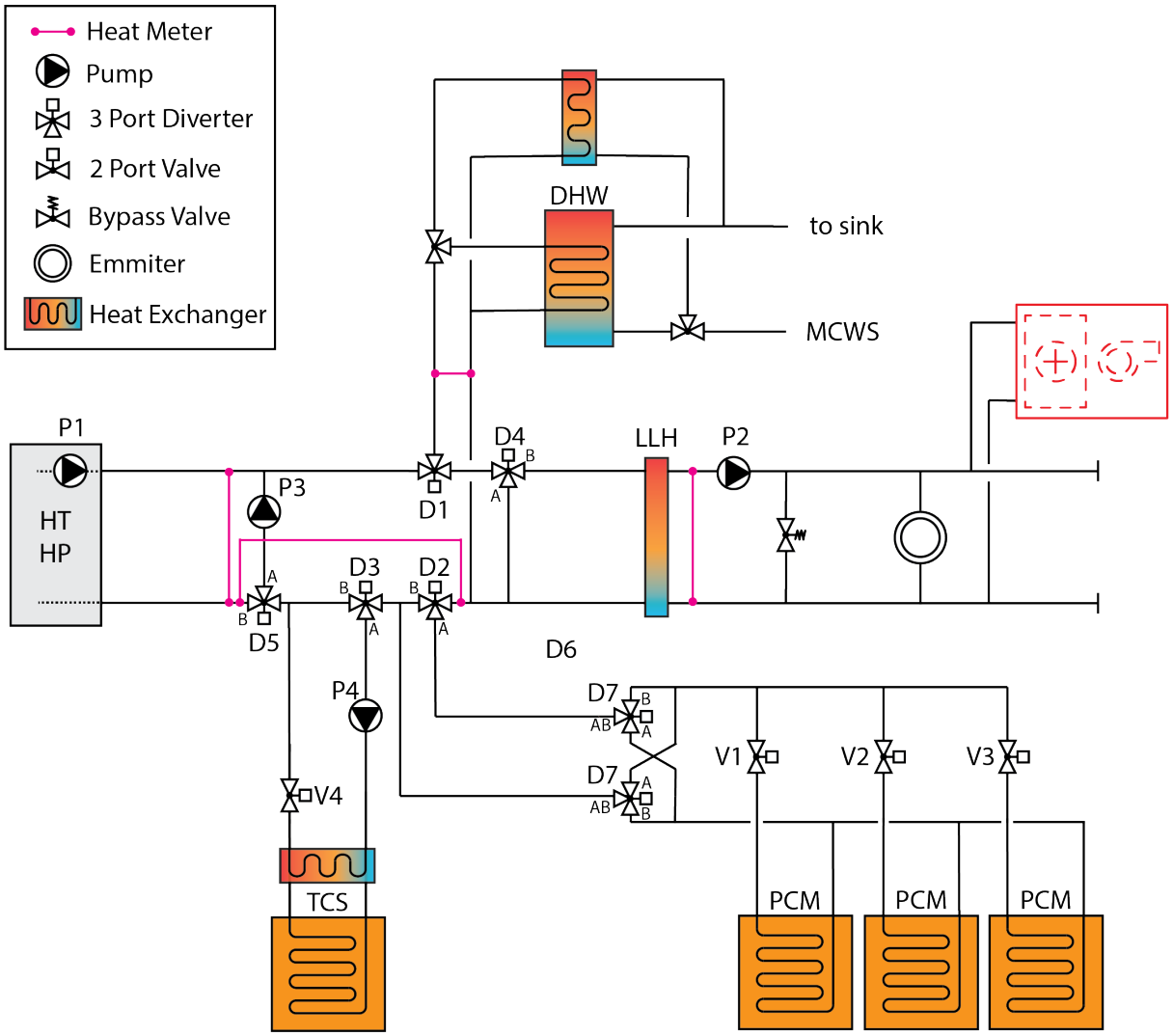
The system under consideration is shown schematically in Fig 1 and is referred to in this paper as the Low Carbon Heating Rig. The system has been developed to allow testing of novel thermal energy storage devices at domestic scale, including interactions with extant heating technologies (Wilson 2023). It is intended to act as a "physical twin" of two such systems installed within real homes as part of the broader research project. Its intended research purpose is to enable developments in the design, operation, and control of the prototype storage devices as well as the associated heating and emission equipment to be tested at system level prior to deployment within homes. The rig also offers the possibility of extension to alternative heat sources and storage devices, enabling testing of scenarios that are not possible within the occupied trial homes themselves. For example, additional inputs are available for connection of a thermoregulated source in place of the heat pump, and alternative heat pump, or (potentially) a solar thermal array.

The system is controlled by a bespoke IoT-connected controller developed by the industrial partner within the research project, enabling both rule-based scheduling and model predictive control of system operation (Barthorpe, 2024). Monitoring is performed using the Open Energy Monitor platform, with extensive electrical, heat and temperature metering in order to evaluate the performance of the system. The hydraulic setup is intended to be highly

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

flexible in nature and allows the thermal storage devices to serve both domestic hot water (DHW) and space heating (SH) demands either directly (i.e. completely removing load from the heat pump) or indirectly by p171reheating the return flow to the heat pump.

Fig. 1 – Schematic representation of the low carbon energy rig



Source: Own elaboration

3. Educational Opportunities

Several avenues for use of the experimental setup in an educational context are apparent. A straightforward possibility is to make use of the equipment within individual investigative research projects; these are an important feature of the final year of our programme and is a requirement of the accrediting body for Engineering courses in the UK (Engineering Council, 2020). Students also have the possibility of undertaking funded, short-duration summer research projects, which again could make use of the research rig as a testbed. However, both these possibilities represent only a minor extension of original aim of the research equipment and may only benefit a small number of students per year. The focus of this abstract is instead

BY-NC-SA 2024, Editorial Universitat Politècnica de València

on delivery at scale within taught modules. First, subject areas that may be addressed are identified Programmes within the institution fall broadly into "foundational" studies within the first two years of the course, followed by more advanced, application-focused studies in years three and four, with students having greater ability to select modules aligned to their interests. The subject areas that may be addressed are considered according to these foundational and advanced levels. Following this, means of delivering practical teaching at scale with limited copies of equipment are explored.

3.1 Learning opportunities at Level 1 and 2

Within the early years of the course, the low carbon heating rig lends itself to supporting students in building links to (i) the foundational theory introduced within the course, and (ii) between the tightly focused practical activities to which they are exposed in these early stages of the course and the real-world applications that build upon them. For example, students already undertake practical activities utilising small scale laboratory rigs that enable them to explore thermodynamic cycles analogous to those found in commercial heat pumps. Having an opportunity to follow up such an activity with an exercise involving the Low Carbon Heating Rig would be of value in cementing foundational learning and placing the learning gained in context. Similar opportunities to extend learning beyond extant small scale lab activities exist within several other engineering focused modules at this level.

In addition to their applied engineering modules, students undertake a series of mathematics modules covering foundational content relevant to engineering. A common challenge encountered by students undertaking these modules is making the link between the mathematical theory and techniques they are presented with and the avenues for applying these in an engineering context. It has been found that this is particularly the case for content focusing on numerical modelling and optimisation techniques within Level 2 of the course. The low carbon heating rig will present opportunities for students to apply these techniques to real data from full size equipment at this stage of the course. This could, for example, be through constructing case studies that requiring student to fit parametric physics-based models to experimental datasets drawn from particular system components, or through applying linear programming techniques to home energy management tasks.

3.2 Learning opportunities at Level 3 and 4

The equipment lends itself to the exploration of open ended and complex research questions that take the students beyond the guided learning of the early years of the course. The aim at these levels is for students to build higher level knowledge (analysis, synthesis, and evaluation of ideas; inter- and trans-disciplinary thinking) through lectures, practical experiences, and group work. Modules include Control Engineering, Advanced Thermodynamic Cycles, Renewable Energy, Industrial Automation and Sustainable

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Engineering Design. There are opportunities for developing advanced lab activities to support learning objectives within a number of these modules. The rig may, for example, be used as a testbed for learning about, testing and validating control paradigms or IoT applications on realistic systems within control and automation modules, or to explore how storage may be used to balance supply and demand within a renewables-dominated energy system. It may also serve as useful case study for system identification and model validation activities, and to generate time series data for statistical modelling and machine learning exercises.

3.3 Achieving delivery at scale

Our existing undergraduate teaching laboratory offering operates on a quantum of 80 students (Beck 2023). In many of our purpose-built teaching laboratories this is achieved by providing multiples of equipment, enabling students to work, for example, in groups of two or four around an individual small-scale rig. Achieving the same throughput with a single experimental rig is rather more challenging, but not without precedent. For example, Garrard et al. (2020) present a pertinent example of a single piece of large-scale equipment being used to deliver teaching to large cohorts at different levels within a Chemical Engineering curriculum. The rig described is a "Pilot Plant" used to manufacture pelletised tablets to a variety of formulations, with students able to control the values of the pertinent process parameters. Key attributes of the produced tablets may subsequently be measured using characterisation equipment within the laboratory.

A key distinction between the rig presented in Garrard et al. (2020) and that considered in the current study is the timescale over which it is useful to gather experimental outcomes. For the Pilot Plant example, production parameters can be set and a batch of tablets produced within a matter of minutes. The slower dynamics of heating systems – and particularly those that incorporate storage elements – mean they lend themselves to much longer acquisition windows, ideally of multiple hours up to days. Nonetheless, elements of the approach proposed by Garrard et al may be adapted to the Low Carbon Heat rig.

A range of approaches are available for addressing the twin challenges of high student-to-equipment ratios and extended acquisition windows. Principal among these is the adoption of group-based activities as a means of maintaining student throughput. As an example, it is suggested that activities could be delivered effectively for groups of around 5 students, enabling delivery for the quantum of 80 students in 16 sessions. A second factor is the use of automation to support the acquisition process. The control system has been developed for real world domestic deployment and is thus required, by necessity, to operate safely for indefinitely long periods without outside intervention. This presents the possibility that an in-person lab activity may be arranged to enable the student group to familiarise themselves

BY-NC-SA 2024, Editorial Universitat Politècnica de València

with the system and to set up their test strategy, and then allow the strategy to play out over the course of an extended period, for example a 24 hour acquisition window. The students could then be presented with their data for further analysis, potentially using Application Programming Interface (API) calls for access. Alternative approaches involve getting groups to obtain data at different times that is then shared with the entire cohort.

There are also options for developing learning and teaching activities to take place before and after the in-lab activities described above in order to maximise the value of these sessions (Garrard & Nichols (2018)). These offline activities could include the development of a research proposal by the group, followed by development of an appropriate design of experiments. Such activities and proposals may be informed by use of the model formulations and datasets generated within the research programme, or those arising from earlier student projects. As the amount of data gathered using the rig grows over time, it is expected that there would be increasing opportunities for students to explore the development of more sophisticated modelling and data analysis techniques, perhaps including digital twin approaches (Jones, Snider, Nassehi, Yon, & Hicks, B. (2020)). The benefit of such offline activities is that they scale well to larger groups. By enabling students to test both control and analysis approaches via numerical methods prior to reaching the laboratory, the benefit of their time using the equipment may be maximised.

4. Conclusions

In summary, this paper presents an initial evaluation of possible methods for incorporating a novel heating and energy storage rig within a Mechanical Engineering curriculum. The particular challenges identified include (i) the ambition to provide a practical, research-led experience to a large number of students with a single research rig; and (ii) achieving timely throughput of student groups given the extended acquisition windows involved. The proposal is very much a work in progress and will be further developed as the rig is commissioned and initial research outputs are gathered. Nonetheless, embedding practical teaching relevant to emerging low carbon energy technologies represents an institutional priority and there is confidence that this can be achieved using the system considered. The work presented is intended as a developing case study that will hopefully be of relevance to educators in the field of energy education.

Acknowledgements

This work was supported by the UK Department for Energy Security and Net Zero (DESNZ) through the Advanced Distributed Storage for grid Benefit (ADSorB) project.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Barthorpe R.J. (2024). *Maximising solar and wind utilisation through distributed thermal storage and predictive control*. 4th Annual Solar and Wind Power Conference. Edinburgh,UK.

Beck S, (2023). On having the right size laboratories. *International Journal of Mechanical Engineering Education*. 2023;51(2):111-122. https://doi:10.1177/03064190221142347

Engineering Council (2020). The Accreditation of Higher Education Programmes (AHEP). Retrieved March 28, 2024 from https://www.engc.org.uk/media/3464/ahep-fourth-edition.pdf

Garrard A, Bangert K, Beck S. (2020). Large-Scale, Multidisciplinary Laboratory Teaching of Fluid Mechanics. *Fluids*, 5(4), 206. https://doi.org/10.3390/fluids5040206

Garrard, A., & Nichols, A. (2018). *A teaching sandwich approach to integrating classroom and practical teaching*. 5th Annual Symposium of the United Kingdom & Ireland Engineering Education Research Network (pp. 87-90). Birmingham, UK.

Jones, D., Snider, C., Nassehi, A., Yon, J., & Hicks, B. (2020). Characterising the Digital Twin: A systematic literature review. *CIRP journal of manufacturing science and technology*,29, 36-52.

United Nations (n.d.). Sustainable Development Goals. Retrieved March 28, 2024 from https://sdgs.un.org/goals

Wilson J. & Barthorpe R.J. (2023) *Experimental characterisation of a novel phase change material heat storage unit for state-of-charge estimation*. In International Renewable Energy Storage and Systems Conference (IRES 2023). Aachen, Germany.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Renewable Energy Management Education: Case Study of Birzeit University

Ahmed Abu Hanieh[a]

[a] Department of Mechanical and Mechatronics Engineering, Birzeit University, Palestine

Abstract

This article aims at shading light on a new master in renewable energy management established at Birzeit University. The programme reflects the high need for the implementation of renewable energy sources in Palestine to substitute for the shortage of fossil fuel and to reduce the impact of CO_2 emissions contributing to clean environment and apply the sustainable development goals put forward by the United Nations. The background and literature review show a wide study of the current sustainability conditions in the Middle East and North Africa region where solar energy is widely used to produce electricity. Sustainability education is strongly encouraged in this region in all universities. Birzeit University has a great interest in obtaining high levels in sustainability and green campus. Many projects and master theses were implemented in the field of sustainability to reach green campus and green education. The renewable energy management master programme is a multidisciplinary programme where it represents the intersection of three faculties: Engineering, Science and Business. The programme aims at graduating experts in establishing, managing and maintaining new renewable energy projects and startups to serve the local society and reduce dependence on conventional fossil fuel. The program is running now with 25 students which meets the expectations and society requirements.

Keywords: Renewable Energy Management; PV solar system; Sustainable Education; Green Campus.

How to cite: Abu Hanieh, A. (2024) Renewable Energy Management Education: Case Study of Birzeit University. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 176-183. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

1.1 Background

Birzeit University (BZU) was established 100 years ago and now it is one of the biggest and oldest universities in Palestine. It has been established in 1924 on 180 acres green hill near Birzeit town. The interest in renewable, mainly solar, energy appeared in BZU as well as in the whole country of Palestine more than 40 years ago by using solar water heating collectors on rooftops. 20 years ago, BZU started using solar Photovoltaic PV systems as a main source of power to produce electricity. It produces now 1.7 MW of electricity that makes around 95% of its electricity consumption using 1 MW solar PV power plant mounted on the ground and 700 kW rooftop-mounted solar PV modules as shown in Fig. 1.

Fig. 1 – Solar PV plants at Birzeit University (1.7 MW)



Source: Own elaboration

The increasing interest in the greening of university campus, resulted in establishing, among other programs, the master program of renewable energy management. The program is an interdisciplinary one where it merges courses and students coming from three faculties; Engineering, Science and Business Administration.

The courses of this program encourage students to be involve in modern teaching and learning techniques through considering students the central axis of the learning process enlarging their mental abilities and opening free thinking gates in their ways leading them to participate in society building through innovation and entrepreneurship.

1.2 Literature review

The stringent global need for sustainable and renewable energy resources is ascending as the quantity of fossil fuel reserve is descending worldwide. This need is reflected in Palestine as well as in all countries. Palestine as one of the Middle East and North Africa (MENA) countries is rich in solar energy and this makes it easier and more feasible to use sun as a main source of energy. Twenty years ago, people of MENA region started to use solar PV and solar concentrated systems to produce electricity.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Some researchers worked on the effect of using micro-grid solar PV systems without connecting to the local grid like (ibrik, 2019). The proposed PV grid aims at covering the electricity needs of household and street lighting is a small area. The problem of this design is that it needs batteries for storage and these batteries need to be replaced and maintained from time to time (Khatib, 2014, Natsheh, 2016). Aysar Yasin and his co-authors discussed in their paper the renewable energy and energy efficiency in Palestine (Yasin et. al, 2021). They concentrated on the barriers and obstacles facing using renewable energy and its importance to reduce CO_2 emissions and build a strong economy. The need for sustainable energy resources was raised by other industrial sectors like stone and marble sector as shown in (Abu Hanieh et. al, 2013). Stone and marble is one of the most important industrial sectors in Palestine and it has a major contribution in the total national income. It is an essential demand to turn it to sustainable sector and one track to do that is by using renewable energy to produce electricity. Ajlouni and Alsamamra (2019) made a complete review of solar energy prospects in Palestine. Most of the Palestinian regions receive about 3000 sunny days per year and an average solar radiation values ranges from 5.4 kWh/m2.day to 6.0 kWh/m2.day. These facts about solar radiation makes Palestine one of the most adequate countries to implement solar energy. Solar implementation can be in domestic household applications like cooling, heating and lighting and even in light industrial and agricultural applications. One of the main challenges facing renewable energy sources is the energy storage. Energy storage in all Arab countries has been tackled by Hasan et. al (2023). The research concentrated on different renewable energy sources like solar PV, Solar concentrated and hydro power. Different energy storage techniques were studied (mechanical, electro-mechanical, chemical, electrical and thermal) and compared to teach other. The paper presents forecast prediction and calculation for the future situation of energy storage.

Al-Saed et. al (2009) discussed the possibilities to advance sustainable education and training of environmental resources in Palestine. The paper took into account the energy and water problems and the capacity building required to improve these resources. Najiba Morrar in (Morrar, 2022) studied the inclusive and equitable access to education and its relationship to the implementation of Sustainable Development Goals (SDGs). The author used different qualitative and quantitative research techniques to show the impact of inequality in education on the 16 SDGs. The greening of university campus was reported to the EU Support and Promotion for Higher Education Reform Experts (SPHERE) in Abu Hanieh (2021). The situation of BZU as a green campus is discussed and the future perspectives were tackled briefly here. Monna et. al (2022) and evaluated the current situation of sustainability education in faculties of engineering. The study took into account the number of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

sustainability courses taught in each Palestinian university specially energy courses and found the gap existing between these numbers and the requirements of SDGs put by the United Nations. The integration of sustainability in engineering education was studied by Abu Hanieh et. al (2016). Different learning and teaching techniques are discussed here showing the inputs, outputs, dynamics and controls of engineering education. A proposed industry-academia relationship is explored in this paper showing the different learning techniques that serve to fill this gap.

This article discusses the importance of renewable energy in education in Palestinian universities. For this reason, BZU established a new master programme in renewable energy management. Next section talks about the structure of the master program and its study plan. Section three tackles the intended learning outcomes of the programme. The goals and impacts of the program on the society are discussed in section 4. While section 5 discusses the inspirations and aspirations of implementing this master program.

2. Program Structure

2.1 Program content

For a student to be admitted to the renewable energy management master programme he must hold a bachelor degree from an accredited university in (mechanical engineering, mechatronics engineering, electrical engineering, electronics engineering, civil engineering, architectural engineering, physics, chemistry or biology). He needs to bring two recommendation letters and to attend an interview upon request. The graduation requirements are summarized by ability of the student to successfully pass 36 credit hours with a cumulative average of 80% or higher.

The two-years master programme in Renewable Energy Management consists of 36 credit hours (CH). The programme comprises 6 compulsory courses (18 CH), 4 elective courses (12 CH) and 6 CH for thesis or two seminars as shown in Table 1.

Table 1- Requirements of master programme in renewable energy management

Requirement	Credit Hours
Compulsory Courses	18
Concentration Elective Courses	12
Thesis or Two Research Seminars	6
Total	**36**

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.2 Study plan

The study plan consists of 36 CH distributed according to Table 2.

Table 2- Study plan of the two years

First year (18 CH)	
First semester (9 CH)	**Second semester (9 CH)**
Research Methodology and Scientific writing	Energy Efficiency & Renewable Energy
Renewable energy and grid integration	Modeling & Simulation
Managerial Economics	Project Management
Second year (18 CH)	
First semester (9 CH)	**Second semester (9 CH)**
6 credit hours from Elective courses	6 credit hours from Elective courses
Track A: Thesis or	Track A: Thesis (Continuous) or
Track B: Seminar I	Track B: Seminar II

Source: Own elaboration

3. Learning outcomes

Upon completing the study requirements, students will have acquired the major intended learning outcomes that they need to compete in the local, regional and international markets. In the field of knowledge and understanding, student needs to develop a thorough knowledge and understanding of the theoretical and applied principles of renewable energy and have a comprehensive and up to date knowledge of solar and wind systems taking into account their economic, environmental, and social impacts. In possessing intellectual or cognitive skills, students must be able to analyze and design thermal solar conversion systems and their applications and be able to analyze, design and implement modern control techniques to renewable energy systems.

On the other hand, in the field of specific and practical skills, students need to have the ability to use computational methods, mathematical and engineering tools in solving complex engineering problems and to be able to use experimental methods in renewable energy. Finally, in the field of general and transferable skills, students must be able to write, review and present project proposals, scientific papers, reports, and technical knowledge effectively and be able to conduct scientific research, design experiments, and process their results.

In order to obtain the foregoing learning outcomes, different assessment techniques have been used. Most of the assessment techniques include research and thinking items like working on research and design projects, reading and analyzing technical papers from journals and conferences, preparing and presenting visuals related to specific topics and making working groups to work on programming using selected software codes.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4. Program effects

4.1 Main goals and specific objectives

The main goals of the Master program in Renewable Energy Management are summarized by preparing graduates to: (1) participate in the development and advancement of the clean and renewable energy profession, (2) implement new technologies and methods in renewable energy systems and (3) be enrolled in International PhD programs.

The program has the following specific objectives: (1) graduating qualified engineers for private and public sectors firms in solar, wind and biofuel sectors, (2) fulfilling the local Palestinian market needs by providing the market with new renewable energy technologies and modern solutions, (3) qualifying students in design, analysis and research capabilities, (4) updating professional graduates with the state-of-the-art technological development and multidisciplinary approach in renewable energy, (5) conducting, disseminating and publishing researches and studies in solar and wind energy systems, (6) raising awareness of the local market about the importance of implementing modern technologies in the fields of green energy, (7) providing opportunities to the current engineering and science students to continue their higher education in renewable energy fields and (8) enhancing the role of the faculty staff of Birzeit University in the national activities and policies concerning renewable energy.

4.2 Societal impact

The program targets bachelor degree holders in Mechanical, Mechatronics, Industrial, Production, Material and Chemical engineering besides to sciences graduates in Physics, Chemistry and Biology. In particular the following groups; Government employees, production and mechanical engineers in industry, fresh graduates of engineering programs, relevant employees working in private sector, relevant employees working in energy related fields and teaching assistant in engineering and science programs at local universities.

The Graduates of the program shall have the following attributes: deep understanding of the research techniques and data analysis in the area of specialization, good knowledge of computational and experimental methods in renewable energy, deep knowledge in one of the specializations areas: solar, wind, biofuel. Other attributes are: good practice in written and oral communication on technical matters and qualified to be enrolled in International Ph.D programs.

Graduate Career Opportunities can be summarized in the potential for employment of program graduates that includes the following: educational institutions; high school,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

polytechnic, and university levels, government engineers in ministries e.g general works, housing, energy and natural resources, Palestinian Standards Institute, planning, water authority, etc. Other employment opportunities are: currently government employees aim to obtain a master degree for promotion and advancement in their career, private sector; consultant offices, industries, automotive. NGOs related to engineering, energy, water, greening and sustainability. Graduates may follow study for Ph.D in international universities.

5. Inspirations and aspirations

To summarize the inspirations leads to establish this master programme, reader needs to know that Palestinians need to cope with the growing Palestinian economy, the escalating of constructions sector, as well as the development of local industry, there is a need for the advancement in renewable energy science and technology and the need for professional and practicing engineers to keep up to date in knowledge and technology. The shown interest locally, regionally and globally in sustainable development and its relationship to energy, environment, manufacturing, constructions and other engineering projects, requires the graduates in general to be ready to apply this concept in Palestine. On the other hand, this is interrelated to the growing interest in new technologies and its application in local industry such as automation, automotive new generations of vehicles including hybrid and electric cars, as well as in construction and buildings for example heating ventilation and air conditioning systems and implementation of building management systems.

The aspirations and dreams required to be accomplished prove that there is a high need to initiate and develop renewable energy studies and research as applied to the local environment (e.g. Energy, manufacturing, automotive, machine manufacturing, automation and control ... etc.). In addition, there is a need for academic staff with master degree in educational institutions (vocational and Industrial-school, polytechnics, and universities). Among the reasons for establishing this new master program in renewable energy is that a good number of Bachelor degree graduates are seeking graduate degree outside Palestine and a good number of employed engineers are looking for development and promotion through earning new master degree, some are government employees others come from private sector. Large number of female engineers and science graduates show their aspiration for master degree; many cannot go to other countries and prefer local universities.

Acknowledgements

No funding has been received for the development of the research.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Abu Hanieh, A. (2021). Greening Palestinian universities through sustainable engineering, renewable energy and solar energy fields. http://hdl.handle.net/20.500.11889/6907, retrieved on 8/1/2024.

Ajlouni, E., & Alsamamra, H. (2019). A review of solar energy prospects in alestine. *American Journal of Modern Energy*, *5*(3), 49-62. http://doi.org/10.11648/j.ajme.20190503.11

Al-Sa'ed, R., Abu-Madi, M., & Heun, J. (2009). Advancing environmental education and training for sustainable management of environmental resources in Palestine. *Applied Environmental Education and Communication*, *8*(1), 30-39. https://doi.org/10.1080/15330150902953456

Hanieh, A. A., AbdElall, S., & Hasan, A. (2013). Sustainable development of stone and marble sector in Palestine. *Journal of Cleaner Production*, *30*, 1-8. https://doi.org/10.1016/j.jclepro.2013.10.045

Hanieh, A. A. M., Hasan, A. A., & AbdElall, S. A. (2016). Integration of Sustainability in Engineering Education in Palestine. *Journal of Engineering Research and Technology*, *2*(1).

Hasan, A. A., Hanieh, A. A., & Juaidi, A. Energy storage: Status and future perspective in Arab countries. *Energy Storage*, e550. https://doi.org/10.1002/est2.550

Ibrik, I. H. (2019). An overview of electrification rural areas in Palestine by using micro-grid solar energy. *Cogent Engineering*, *6*(1), 1638574. https://doi.org/10.1080/23311916.2019.1638574

Khatib, T. (2014). Optimization of a grid-connected renewable energy system for a case study in Nablus, Palestine. *International Journal of Low-Carbon Technologies*, *9*(4), 311-318. https://doi.org/10.1093/ijlct/ctt007

Monna, S., Barlet, A., Haj Hussein, M., Bruneau, D., Juaidi, A., & Baba, M. (2022). Sustainability integration in Palestinian universities: a focus on teaching and research at engineering faculties. *International Journal of Sustainability in Higher Education*, *23*(7), 1709-1729.

Morrar, N. (2022). Inequalities In Education And Sustainable Development Goals: A Case Study Of Palestine. *Vegueta. Anuario de la Facultad de Geografía e Historia*, *22*, 11. https://doi.org/10.5281/zenodo.7346920

Natsheh, E. M. (2016). Power generation of solar PV systems in Palestine. *Applied Solar Energy*, *52*, 193-196. https://doi.org/10.3103/S0003701X16030105

Yasin, A., Camporeale, C., Alsayed, M., Del Ciello, R., & Yaseen, B. (2021). Investing in renewable energy and energy efficiency in Palestinian territories: barriers and opportunities. *International Journal of Photoenergy*, *2021*, 1-11. https://doi.org/10.1155/2021/7482356

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Project-based education: Business assignment manual

J.B.M. Lauwerijssen

ROC Midden Nederland , Tech Campus Nieuwegein, Netherlands

Abstract

Shaping authentic and contemporary education together with companies from the region. Students will learn new skills in a realistic environment. Project-driven education fits well with shaping realistic and authentic assignments together with companies. The benefits of project-based education with the direct involvement of a company or companies come from the close interaction between school and workfield. Teachers are forced to work close together with a company wich inforces charing of current knowledge needed. Students in return work on actual issues wich are relevant and meaningful. Companies have a say in the offered curriculum and also get an early insight in possible labour potential.

Keywords: Project-based education, authentic and realistic assignments, meaningful education, knowledge sharing.

How to cite: Lauwerijssen, J.B.M. (2024) Project-based education: Business assignment manual. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 184-192.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Together with the business community Tech Campus Nieuwegein, a college of ROC Midden Nederland, creates a hybrid learning environment that gives students more choice in educational content. Co-creating education can lead to more current and authentic education. A close collaboration with companies offers teachers the opportunity to evaluate the currency of their knowledge base.

This collaboration with the business community can be achieved in various ways. For example: developing the curriculum together, giving guest lectures and offering internships for students. Starting in 2019, the `Build Environment and Engineering' team of Tech Campus Nieuwegein has been offering in-company assignments for students to carry out. So far these assignments only have been carried out with European qualification framework (EQF) level-4 students in Build Environment and Engineering. With these students it has been proven to be a powerful teaching method. At the time of this writing sustainable agreements have been made with at least sixteen companies. Currently between ten and fifteen company assignments are structurally offered in the level-4 courses Build Environment, Engineering and Civil Engineering. The teachers involved work together with the various companies. Multidisciplinary education that has so far been well received by almost everyone involved.

1.1 Business assignments according to the project-driven education model

The project-driven education model used, appears to fit well with the way of working at various participating companies. The company fulfills the role of customer/client, is a professional expert in specific areas and is often able to transfer broad procedural knowledge since they have to keep up with current laws and regulations. Students learn partly at school and partly at the company. Preference is given to a division of one day at the company and one day at school. This provides an authentic context one day a week and it encourages regular contact with the companies. Experience shows that an assignment from a company without further active involvement is less powerful than when the company takes an active role. Since the teachers at school are responsible for the students' learning process, active communication with the companies is very important. What seems to work well is appointing different core teachers to supervise a group of students. The core teachers must actively maintain contact with the associated companies. Unto the current school year a number of approximately twelve teachers of Tech Campus Nieuwegein have worked together with approximately sixteen companies. However not at the same time. Simultaneously about eight teachers and about four to six companies are involved. As indicated earlier, a supportive attitude towards each other is important.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Project-based education at Tech campus Nieuwegein

Project-driven education fits well with shaping realistic and authentic assignments together with companies. By using a clear teaching methodology throughout the entire course, students learn to shape projects in a structured way. Although there are different approaches to successfully completing a project, the majority of the compagnies the Build Environment and Engineering team collaborate with, are familiar with a six-phase project methodology. The word project can also be seen as an abbreviation for a number of English keywords: Purpose, Result, Organization, Joy, Excellence, Communication, Teamwork. As evidenced by the word Joy , carrying out a project and preferably concluding the project with a good result is something to be happy about (Both & Schroevers, 2007).

ROC Midden Nederland focuses on students who are motivated, experience ownership, feel involved and have control over their own learning process. With a non-linear curriculum, good guidance from teachers, tailored feedback and close collaboration with the business community, ROC Midden Nederland is committed to achieving these goals. Project-based education offers a more holistic approach that trains students across disciplines. It appears to be a good method to give substance to the vision and mission of Tech Campus Nieuwegein. The experience to date is that both students and teachers from the Build Environment and Engineering team of Tech Campus Nieuwegein are energized by project-based education. Feedback from students usually states that the project assignments are appealing and meaningful (Bosch & Koch, 2020).

2.1 Project steps

The Build Environment and Engineering team of Tech Campus Nieuwegein uses the guidelines from Both & Schroevers (2007) to form project-based education. Six consecutive process steps are completed each time. These six steps, also referred to as phases, are successively: Initiation phase, Definition phase, Design phase, Preparation phase, Realization phase and the Aftercare phase.

2.1.1 Initiation phase

In this phase, students form the project groups. Various roles can be distinguished within a project group. In any case, one is required to be appointed project leader. In addition, roles can be designated such as: designer/draftsman, technical executor, maintenance specialist, etc. Depending on the assignment, relevant roles should be assigned within the project group. Every role has different tasks and responsibilities. The role of the project leader is very important, as it directs the creation and compliance of the action plan and the project planning. In addition, the project leader has the duties of chairing meetings and communicating meeting agenda and minutes with the teacher and any contact person within the company. The project leader talks with group members on compliance with the plan.

2024, Editorial Universitat Politècnica de València BY-NC-SA

In the initiation phase, choices must be made about how the project will be tackled. At the end of the initiation phase, it must be sufficiently clear what the end result will be and what it certainly must not be. The problem definition, working method, feasibility, etc. must be clearly expressed. (Both & Schroevers, 2007, p. 194)

2.1.2 Definition phase

In this phase the client's requirements and wishes are recorded. Any conflicting requirements must be recognized and discussed with the client. A clear distinction between the functional requirements (for example: is the end result suitable for what it is intended for?) and operational requirements (is the end result easy to maintain/control?) is described. Carrying out market research and creating a project plan with clear deadlines are important parts of this phase. At the end of this phase there must be a project program approved by the client. (Both & Schroevers, 2007, p. 197)

2.1.3 Design phase

The main goal of this phase is the realization of the project design. The project design actually answers the question of how the project will lead to the desired result. A cost overview must included in the design proposal. The ideas should be discussed with the client, any additional wishes, if feasible, are added to the design. After this, a new cost figure is created, which must again be discussed with the client. A detailed planning in time for the design phase and a global planning for the remaining phases is an important part of this phase. (Both & Schroevers, 2007, p. 200)

2.1.4 Preparation phase

In the preparation phase, matters from the design phase are developed further. The design phase and preparation phase overlap, so to speak. Activities from the first draft are divided into sub-activities for the designated group members. Ensuring that construction schedules, working drawings, production drawings, production schedules, parts lists, material lists, etc. are up to date is an important part of the preparation phase. (Both & Schroevers, 2007, p. 202)

2.1.5 Realization phase

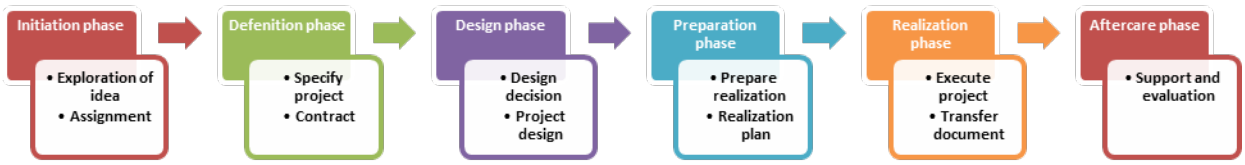
During the realization phase, everything described in the project plan is actually implemented. The first four phases were mainly focused on thinking about the project and the steps to be followed, the realization phase is mainly focused on doing it. Any product deviations must be discussed with the client. Proposals for improvement are part of this. A satisfied client is an important goal to achieve here. With proper consultation, a mistake does not have to prevent this to stand. (Both & Schroevers, 2007, p. 205)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.1.6 Aftercare phase

This final phase is aimed at evaluating and assessing the project. Student have to check whether all documents are complete and all signatures have been made during the project. An important part of the aftercare phase is a presentation of the project in which feedback is requested. A good project evaluation can lead to a better approach for a new project. Evaluate and reflect on all activities and results achieved during the project therefore are of great importance. (Both & Schroevers, 2007, pp. 207-210)

Figure 1 - Flowchart six phase project aproach



Source: made by author based on models from Both & Schroevers (2007)

3. Student in control

Project-based education requires a high degree of self-direction from students, especially in the higher grades. Self-management is not always easy, but it is a powerful way of learning. Self-made choices in what and how one learns lead to better and more sustainable results. However, self-management can also quickly turn into frustration when students get stuck on a certain part of the project for (too) long. Students often lack sufficient prior knowledge to ask the right questions (Luken, 2008). Student coaches have the sometimes difficult task of signaling in a timely manner that students have gotten stuck and can no longer progress without help. Providing essential information and training necessary skills, is an important part of project-based education. Hattie & Timperly (2007) state that providing effective feedback to the student is also an indispensable part of good education.

3.1 Feedback

According to Hattie & Timperly (2007) there are multiple studies into learning effects that show that feedback given at the right time, leads to high learning outcomes. Not only an occasional tap on the shoulder or a little push in the back, but also substantive feedback is of great importance. Interim feedback is essential for the student's learning process. To ensure that all students receive feedback, a number of fixed feedback moments are scheduled during the teaching periods, usually halfway and at the end of each period (a period is usually ten weeks). Feedback is given based on various matters that may vary slightly per assignment.

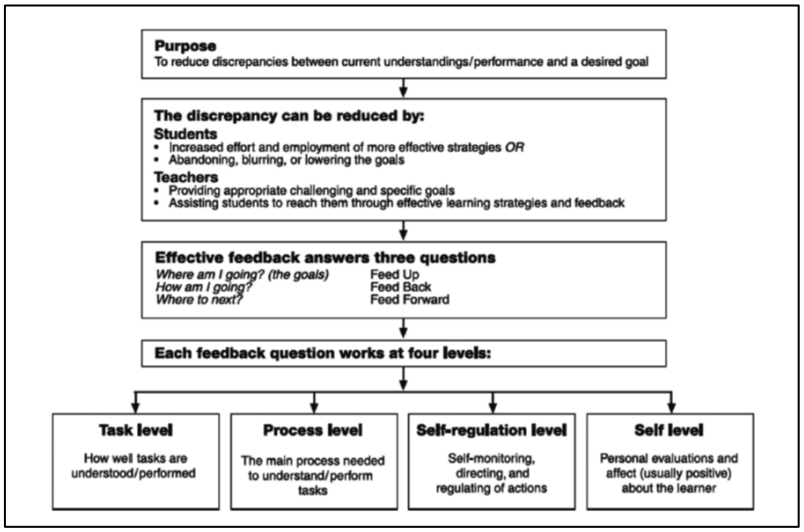
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

There are a number of desired outcomes from the students that are considered with every project assignment;

- Formulate and reporting
- Plan by Approach and schedule
- Design (technical design using CAD)
- Working posture
- Communication
- Quality assurance
- Presentation

The desired outcomes are the guideline in order to give feedback to the students at the right time when needed. To do this together with untrained representatives from companies requires a lot of attention from the responsible teachers. Developing and learning of giving good feedback is a skill that needs continues attention. Besides the often not knowing what the skills in this matter from de company representatives are, also some teachers might not be as good equipped with these skills. It remains a challenge to give the students the feedback at the right time and right level they need. It requires a lot of synergetic working together of the teachers, company representatives and of course the students. Within the team Build Environment and Engineering interim assessments of project progress as well as the end assessment are always given by two teachers and preferelaby a representative of the involved company. By having these teachers assessing the students together, they also gain mutual insight into each other's views and interpretation of the work done by the students. It is important not to form the same pairs each time, but to rotate in them. This to keep the vision on education as broad as possible within the team.

Figure 2 - the power of feedback flowchart



Source: Hattie & Timperly (2007)

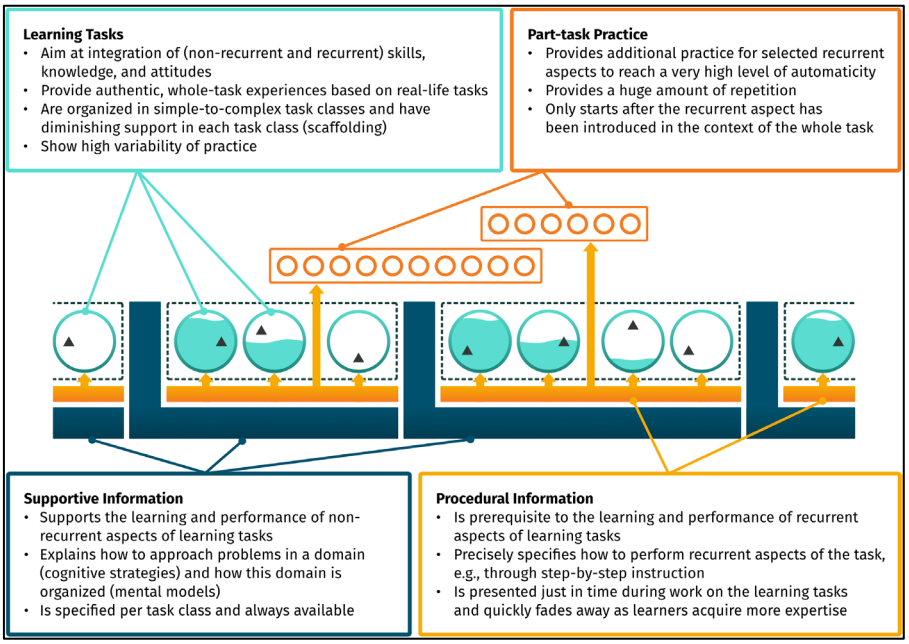
BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.2 Instructional design

Many schools in vocational education and training (VET) in the Netherlands use the four components instructional design model (4C/ID model) in parts of the curriculum. The project-based education described in this paper is no different. Van Merriënboer (1997), one of the key developers of the 4C/ID model, states that it is a very suitable educational instruction design for education aimed at complex skills. Complex skills refer to the ability to consciously process related tasks. The 4C/ID model always focuses on an integral authentic learning task. In order to properly perform this learning task, skills training is required, the so-called sub-task exercises. Underlying, and somewhat independently of the concrete learning task, supporting, or procedural, information must be provided to students. More substantive information, which is given exactly when a student needs it, is of great importance during the execution of the learning task (just in time information). What is referred to as a learning task in the 4C/ID model, is referred to as a project assignment in project-based education. During the training, the project assignments should become more complex in nature and less guidance of the students should be provided according to the 4C/ID model.

Members of the team Build Environment and Engineering of Tech Campus Nieuwegein find that the business assignment should always described together with the participating companies. The 4C/ID model is the basis for describing and designing the project assignments. By actively shaping the assignment and components of the assignment together with a company, it contributes to knowledge sharing between the company and the supervising teachers. It helps in maintaining an up to date knowledge base of the teachers.

Figure 3 - Four-Component Instructional Design



Source: (4CID.org, 2024)

2024, Editorial Universitat Politècnica de València BY-NC-SA

4. Coaching

Personalized education on the Tech Campus Nieuwegein focuses on the development of; control over the learning process, ownership, motivation and involvement of the student. The Tech Campus Nieuwegein does this by focusing on good guidance, providing feedback, offering a non-linear curriculum and collaboration with the business community. Designing personalized education is tailor-made, there is no immediate blueprint that applies to all teams (Bosch & Koch, 2020). The vision of the Tech campus Nieuwegein serves as a guideline for project-based education in which we want to do justice to personalized learning as much as possible. Teacher teams at Tech Campus Nieuwegein are still learning this.

4.1 Teacher rolls

Strengthening direction, ownership, motivation and student involvement largely requires coaching according to Bosch en Koch (2020). In addition to coaching, there are a number of important guidance roles to be fulfilled in project-based education. For example, providing the necessary knowledge base is an important task for supervising teachers. This concerns both broader procedural information and substantive information and practicing the sub-tasks. Supervisors should be aware that students will not easily discover things on their own according to Valcke (2007). Supervisor roles such as pedagogue, didactician, subject expert, leader, instructor, coach, host, presenter, confidant, etc. . . can be equally important at a certain point in the training. It is good to take into account the fact that teachers usually have a different teaching style. Teachers in the team Build Environment and Engineering are no different to this. This is the professional independence that Hattie (2008) believes teachers enjoy. The different teachers, and therefore styles of guidance, can strengthen the guidance given to students. Of course, the different styles can also get in each other's way and negatively influence the students' learning process. It is therefore highly recommended that the supervising teachers regularly discuss with each other and share their individual visions on education. Teachers who inspire, support and advise each other in their own development and that of colleagues, contribute to their own and each other's professional development (Hattie & Timperly, 2007).

5. Conclusion

The team Build Environment and Engineering shapes the vision and mission of Tech Campus Nieuwegein through project-driven education. There is an important task for the supervising teachers in project-driven education. The project assignments should increase in complexity during the training. The guidance should be reduced, but not in too large steps, as there is a lurking risk that students will get stuck. Providing targeted feedback to students, partly aimed at the student group and partly individually, is essential. It can be a challenge to offer the perfect education for each individual student. Good guidance is very decisive for student

BY-NC-SA 2024, Editorial Universitat Politècnica de València

success. Guiding students in project-based education largely consists of coaching. However, it does not consist solely of coaching. Students must be taught sufficient knowledge and skills to be able to carry out the assignment properly. Students should not be expected to already have this prior knowledge or to be able to find and learn it independently. Teachers can use their individual teaching styles to strengthen each other. This requires an inspiring, supportive and advisory attitude towards each other. And in order to stay well informed of the latest developments in the business community, the teachers must actively shape the assignments together with the participating companies. Knowledge sharing is an important component of business assignments.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

4CID.org. (2024, januari 31). *4C/ID Home - Four-Component Instructional Design.* Four-Component Instructional Design.: https://www.4cid.org/

Bosch, M., Koch, R., ROC Midden Nederland, Frisse Blikken, CINOP-ECBO, & Hogeschool voor de Kunsten Utrecht & Onderwijs124. (2020). *Hoe de Tech Campus werkt aan gepersonaliseerd onderwijs*. https://ecbo.nl/wp-content/uploads/sites/3/Samen-bouwen-aan-leren-20111-ROC-MN.pdf

Both, W., & Schroevers, R. (2007). *Technische bedrijfskunde 1: Plannen, uitvoeren en controleren.* Noordhoff Uitgevers.

Hattie, J. (2008). *Visible Learning: a synthesis of over 800 meta-analyses relating to achievement.* https://minerva-access.unimelb.edu.au/bitstream/11343/31622/1/281182_161493.pdf.

Hattie, J., & Timperly, H. (2007). The Power of Feedback. *Review of Educational Research, 77*(1), 81-112. https://doi.org/10.3102/003465430298487

Luken, T. (2008). De (on)mogelijkheid van nieuw leren en zelfsturing. *Loopbaanleren: Onderzoek en praktijk in het onderwijs.*, 127-151. https://hbo-kennisbank.nl/details/sharekit_fontys:oai:surfsharekit.nl:08dd3416-b511-465b-819b-6421c49f2046

Valcke, M. (2007). *Onderwijskunde als ontwerpwetenschap - een inleiding voor ontwikkelaars van instructie en voor toekomstige leerkrachten. (4th completely revised and extended edition).* https://biblio.ugent.be/publication/423765.

Van Merriënboer, J. J. (1997). *Training Complex Cognitive skills: A Four-Component instructional design model for technical training.* http://ci.nii.ac.jp/ncid/BA48296431.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

S3 INDUSTRIA: A collaboration project between vocational education training and industrial sector

Ramon Diaz[a], Aina Casabán[a], Lorena Muñoz[a], Elisa Adell[b], Paula Guillén[c] and María José Sales[d]

[a] Department of Vocational Training Education, IES Doctor Peset Aleixandre, Paterna, Spain
[b] Department of Vocational Training Education, IES Federica Montseny, Burjassot, Spain
[c] Department of Vocational Training Education, INS Pompeu Fabra, Badalona, Spain
[d] Educational innovation projects, VÉOLO, Spain

Abstract

There is an obvious need to take care about our future. This is the idea behind the Agenda 2030 and the Sustainable Development Goals (SDG) and this is also why we bring together in this project the three pillars to reach these goals: Students, schools and industry. Besides, Vocational education training (VET) must also face this challenge by adapting to the new requirements of the industry market, which sometimes requires a high level of specialization.

In this program we will carry out several learning experiences with VET students from 3 different schools from Valencia and Badalona under the umbrella of atmospheric air pollution and indoor air quality. Thus, after the proper training for the professors carried out by state-of-art companies in this field, the schools were equipped with the necessary specialized technology and the students form all groups have developed their research in the different subjects. Finally, the students will share their work in a public event. As mentioned, important companies in the area will be engaged in every step, showing the increased implication of industry in environmental protection.

Keywords: Vocational training education; industry-school collaboration; environmental monitoring, air pollution, Sustainable Development Goals (SDG).

How to cite: Diaz, R.; Casabán, A.; Muñoz, L.; Adell, L.; Guillén, P. and Sales, M.S. (2024) S3 INDUSTRIA: A collaboration project between vocational education training and industrial sector. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 193-201. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. Specifically, SDG No. 4 seeks to ensure inclusive, equitable, quality education and promote lifelong learning opportunities for all. In addition to being an end in itself, education is considered a key instrument for achieving all the SDGs (Romero and Careaga, 2017) and in particular education for sustainable development (UNESCO, 2017).

Climate change is one of the most important challenges for the economy and society in the coming decades, and air pollution is now recognized as the single biggest environmental threat to human health (WHO, 2021). Respect and protection of the environment as well as safety and prevention of occupational risks is not only a legal obligation but also a market requirement. Vocational training must also face this challenge by adapting to the new requirements of the industry market, which sometimes requires a high level of specialization. The partnership between educational institutions and companies is necessary to reduce the gap between education and the labor market in the context of the rapid development of science and technology, changes in the field of employment and the need to ensure the competitiveness of companies and the national economy (Litovchenko, 2016). In this context, the transfer of knowledge to students is essential to ensure high educational quality, however, there are few case studies publications that promote the transfer of learning and the application of work skills in vocational training, so it is necessary to promote these (Garrido et al., 2017).

The methodology used to prepare students is important, as they directly influence the acquisition of specific skills and their application in the workplace (Gutierrez and Villegas, 2015). Although some practical experiences have been published for other educational levels (Llopis, 2021), there is little information about the use of innovative methodologies to work on sustainability with students, specifically vocational training .The curriculum of VET teachings includes sustainability, safety and health in various modules; however, the teaching teams do not have adequate teaching resources or facilities in the educational center to create learning situations that represent practical cases close to the real work environment.

2024, Editorial Universitat Politècnica de València BY-NC-SA

2. Objective

The objective of S3 INDUSTRIA is to improve current training in Sustainability, Safety and Health, to enhance student access to the labor market, specifically in the industrial sector and from various training cycles. Furthermore, the project aims to establish a partnership between vocational education training and companies to meet current labor demands.

3. Methodology and Development

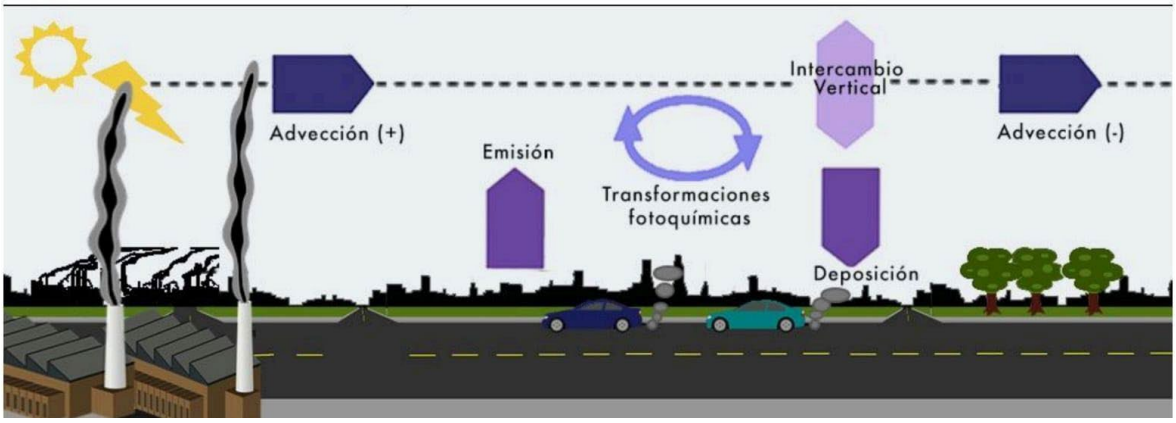
3.1 Specific training programme for teachers

In a first step, and in order to maximize the quality of the results from this project, the teachers from 3 different VET schools are trained in air pollution, including the physicochemical behavior of contaminants in the atmosphere, effects in human health and environment and the approaches for environmental monitoring and data management. The training course is organized by VÉOLO, a Spanish company with demonstrated experience in educational innovation projects related to air pollution.

The training program includes a first specific theoretical part on air pollution, both indoor and ambient air, and a second practical part, applying current knowledge and techniques of control and monitoring to design learning experiences for students at middle and superior grades in VET in the field of chemistry and environmental health.

An example of this specific training programme for teachers is shown in figures 1 and 2. Specifically, figure 1 illustrates a summary of the physical and chemical processes that can occur in airborne contaminants whereas figure 2 shows the effects of air pollution on human health as an estimation of the loss of life expectancy caused by several factors and highlights the impact of air pollution which is in the range of tobacco or cancer.

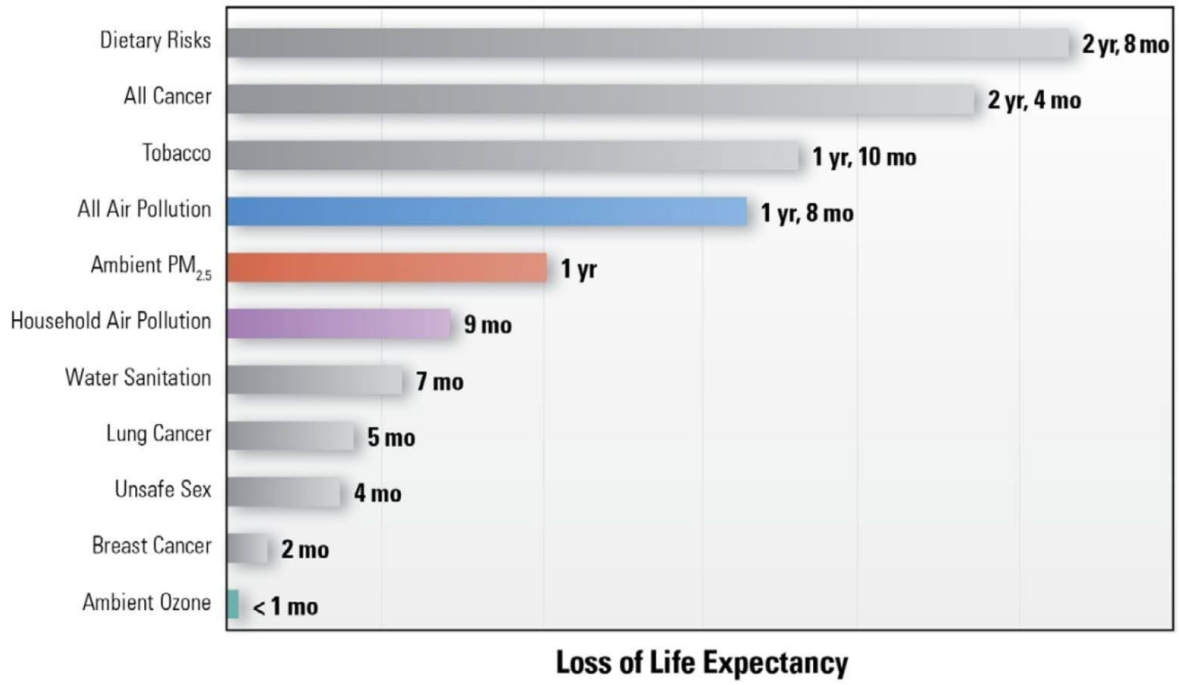
Fig. 1 – Atmospheric air pollution: main physical and chemical processes.



Source: "Veo el aire que respiro" Course, VÉOLO.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 – Effects on human health caused by environmental air pollution: Loss of life Expectancy.



Source: E Health Effects Institute. 2019. State of Global Air 2019. Special Report. Boston, MA:Health Effects Institute.

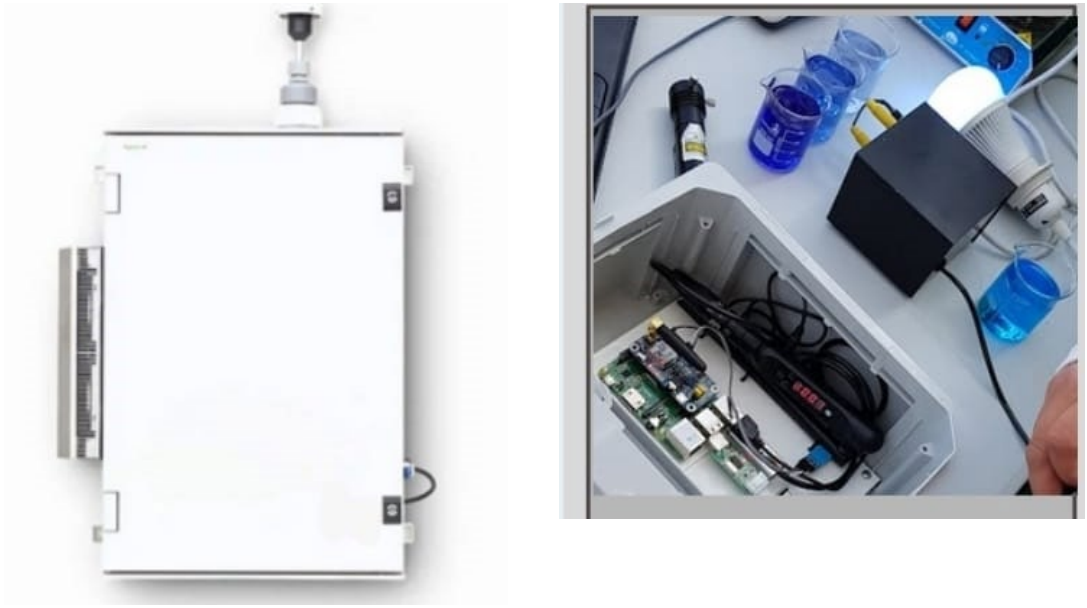
3.2 Development of learning situations

A learning experience to be carried out with the VET students will be defined as the final outcome of the teacher's training. Technology for monitoring air pollution is being used to develop the educational projects for students where, not only the data collection but also managing this big data, to study the environment and workspaces has been carried out with the final goal to identify potential environmental problems. Thus, the technology devices shown in figure 3 are being used for indoor and outdoor air pollution control around industrial sectors. The first (indoor device) is designed to obtain data about work space safety while the second allows real-time quantification of atmospheric air pollutants.

The learning experiences provide significant learning to the students and the development of STEM skills. The methodology is based on the study and simulation of practical cases. The students have applied the tasks carried out by the company's technical staff, and they have evaluated the results with a critical spirit. An innovative teaching resource is the air quality monitoring network made up of IoT sensors and a platform to visualize, graph and analyze measurements. With this resource, digital, mathematical and scientific-technological competence is developed using measurements of environmental parameters in real time. This approach has been tested in the field of vocational training in the Erasmus+ project, ICT-AIRE, and the results have been very satisfactory.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 3 – Measuring devices used for real-time air pollution monitorization: External (left) and internal (right) measurement devices that include data acquisition and communication systems.



Source: VÉOLO.

3.3 Sharing project results

One of the challenges is to share project results widely with society in general and with industry specifically, so the final activity of S3 INDUSTRIA project will be a public event where students from the 3 participant schools will present their learning experiences and the results of their activities by means of oral and poster presentations. This event will be attended by other students and teachers from invited schools, representatives of the public administration and the business sector of the Valencia region. This meeting is expected to put in contact and create synergies between future professionals and the industrial sector.

4. Results

4.1 Motivation and Evaluation Survey

A survey was conducted before or at the beginning of the development of the different learning experiences to evaluate the motivation of students towards the experiences proposed. From the results it can be concluded that 72% of the surveyed considered this learning approach as beneficial or highly beneficial. Furthermore, up to 84% considered that this project will have a positive impact in both their formation and professional development career.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

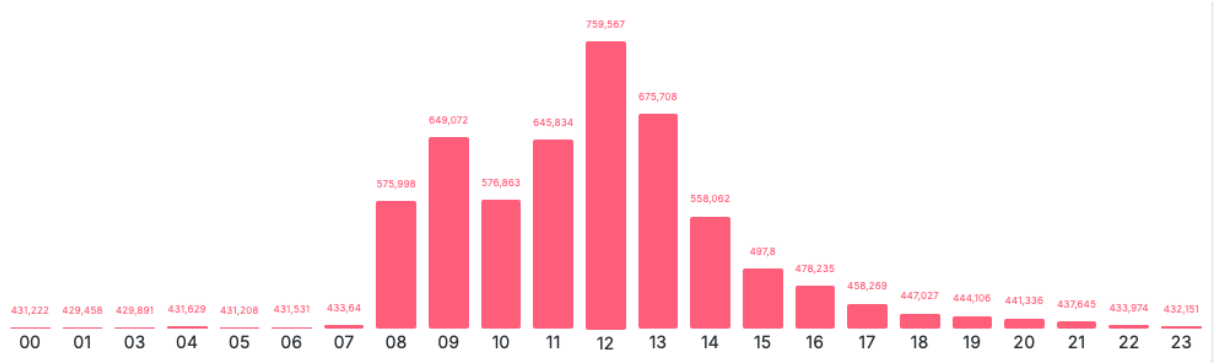
4.2 Learning situations

After finishing the initial training, a total of 21 teachers and 14 learning situations have been designed and are being implemented. Thus, a total of more than 100 students from the 3 schools will participate in at least one project.

To exemplify some of the data obtained by students working with the different devices in some of the learning situations:

A) CO_2 levels (ppm) in the classroom. Following figure shows the standard hourly concentration of Carbon Dioxide in one of the classrooms which has a direct effect on students' performance.

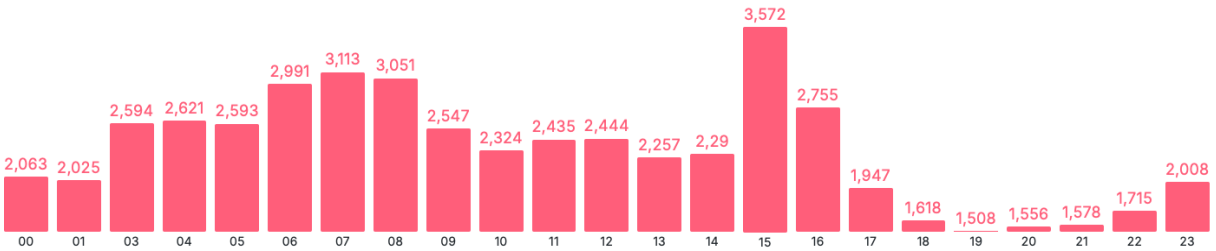
Fig. 4 – Average hourly concentration of CO_2 (ppm) measured with an INDOOR device in a classroom over a period of 8 consecutive days (from 15 to 23 April 2024).



Source: Grafana data platform, CaixaBank Dualzia Project.

B) $PM_{2,5}$ levels ($\mu g/m^3$) in the classroom. In figure 5, the movement of students can be observed.

Fig. 5 – Average hourly concentration of $PM_{2,5}$ (ppm) measured with an INDOOR device in a classroom over a period of 8 consecutive days (from 15 to 23 April 2024).

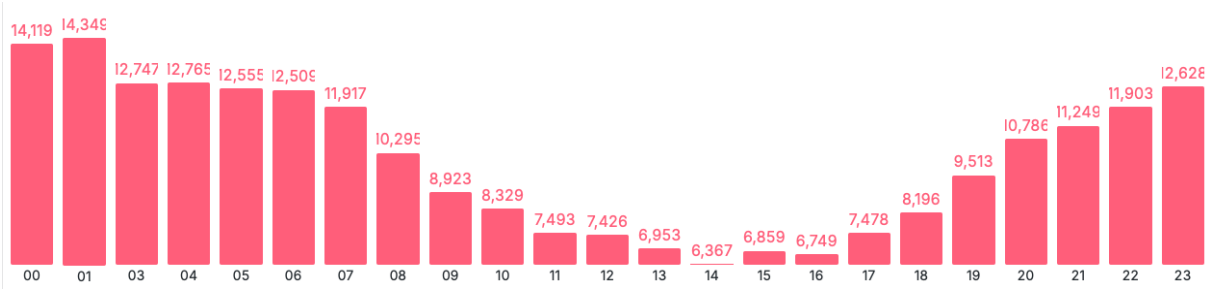


Source: Grafana data platform, CaixaBank Dualzia Project.

2024, Editorial Universitat Politècnica de València BY-NC-SA

C) PM2,5 levels (µg/m³) outside the Moehs company. The impact of weather conditions as well as traffic and industrial pollutions can observed in the average hourly distribution in figure 6.

Fig. 6 – Average hourly concentration of PM2,5 (ppm) measured with an OUTDOOR device at the Moehs company over a period of 2 consecutive months (from 15 to 23 April 2024).



Source: Grafana data platform, CaixaBank Dualzia Project.

4.3 Final event

As mentioned in the methodology section, the final event to share results is programmed on June 10th where most relevant companies in the area have been invited. The idea is not only to present the results obtained by the research performed but also to create an environment where companies, professors and students can meet and have the opportunity to get feedback on current industrial and career situation. Thus, the expected outcome is to improve the employability of the students by helping students to understand the needs of the market while showing industry the specific training they have carried out.

It is important to highlight the MOEHS (pharmaceutical company) contribution to the project. MOEHS has been actively engaged in the follow-up as well as AVEMCAI (Association of companies focused in air quality control) which has contributed to the teachers' training.

5. Conclusion

Educational centers are the key agents in the education of future citizens who will contribute to the implementation of the SDGs. This project will have a positive impact on the teachers, students and industry. The participating teachers will be trained in one of the main challenges of the 21st century: air pollution, and in a teaching methodology to face this challenge from the field of vocational training. Participating students will have an opportunity to expand their knowledge on sustainability, safety and health. They will learn current techniques to analyze air quality and learn about the measures adopted in the industry to be more sustainable. The transfer of education center-company knowledge will allow teachers to better understand the needs of the sector and prepare students. The company's staff will be able to contribute to the training of future professionals and attract talent.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

It is hoped that the results of the S3 INDUSTRIA project can be replicated in other vocational training centers in order to have an impact on the maximum number of students possible. In fact, the huge amount of data generated in this project can be used for a great variety of learning situations applied to different subjects but always related to sustainability and air quality.

Acknowledgements

S3 INDUSTRIA project is supported by CaixaBank Dualiza y FPEmpresa in the framework of the Dualiza grant, 2023-2024.

We thank our colleagues from IES Doctor Peset Aleixandre (Paterna), IES Federica Montseny (Burjassot) and Institut Pompeu Fabra (Badalona) who provided insight and expertise that greatly assisted the project and engage with great enthusiasm in this adventure.

We would like to highlight the support received and the involvement of the company MOEHS in the training activities that will be developed in the S3 INDUSTRIA project and to the company VÉOLO which brings to the project an innovative methodology to develop learning experiences to address the challenge of air pollution.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Health Effects Institute. (2019). State of Global Air 2019. Special Report. Boston, MA. https://www.stateofglobalair.org/sites/default/files/soga_2019_report.pdf

Olson, B.V., McGuire, C., Crawford, A. (2021). Improving the Quality of Work Life: An Interdisciplinary Lens into the Worker Experience. In: Dhiman, S.K. (eds) The Palgrave Handbook of Workplace Well-Being. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-30025-8_3

Education for Sustainable Development Goals: learning Objectives. (2017). En UNESCO eBooks. https://doi.org/10.54675/cgba9153

Garrido, M. F., Davids, A. I. R., González, J. M. J., & Soto, Á. P. G. (2017). Análisis sobre el aprendizaje y la aplicación de las competencias generales en el contexto laboral. Estrategias de colaboración entre la formación profesional, la universidad y la empresa. Educar, 53(2), 333-355. https://doi.org/10.5565/rev/educar.889

Gutiérrez, D. C., & Villegas, E. G. (2015). The Importance of teaching Methodology in Higher Education: A Critical look. Procedia - Social and Behavioral Sciences, 174, 377-382. https://doi.org/10.1016/j.sbspro.2015.01.677

LLopis, A. N. (2021). Taller móvil de medida de la contaminación. Modelling in Science Education and Learning, 14(1), 57. https://doi.org/10.4995/msel.2021.14011

2024, Editorial Universitat Politècnica de València BY-NC-SA

Lytovchenko, I. (2016). Development of higher education–industry partnership as a factor of corporate education efficiency in the USA. Наука і освіта, 37(10), 98-102. https://doi.org/10.24195/2414-4665-2016-10-19

Romero, A. G., & Careaga, S. A. (2017). El papel de la universidad y la Cooperación Universitaria al Desarrollo en el nuevo escenario de la Agenda 2030. Revista Española de Desarrollo y Cooperación, 41, 13-24. https://dialnet.unirioja.es/servlet/articulo?codigo=6187114

World Health Organization (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. https://iris.who.int/handle/10665/345329.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Exploring partnerships between universities, industry and governments to integrate Sustainable Development Goals

Konstantinia Nikolaidou[a], Sofia Pavlidou[b], Ioannis Karagiannis[a] and Lefteris Topaloglou[a]

[a] Department of Chemical Engineering, University of Western Macedonia, Greece
[b] Department of Mechanical Engineering, University of Western Macedonia, Greece

Abstract

The purpose of this paper is to examine the relationship between universities, industry, and policy makers in order to prioritize and achieve the United Nations' Sustainable Development Goals (SDGs) at a local level. Within the framework of the ERASMUS project titled "Embedding EU Green Deal and Just Transition in Teaching and Learning-JUST4ALL," interviews with local stakeholders were conducted in all six partner countries, namely Bulgaria, France, Greece, Spain, Cyprus, and Serbia, for the purpose of gaining deeper understanding of the quadruple helix's perspectives. There are several chances for major cooperation and contribution towards a sustainable future that are highlighted by the interrelationships and interactions that exist between universities, industry, and stakeholders in policymaking.The paper recommends enhancing collaboration between universities and governments, prioritizing interdisciplinary research and education for Sustainable Developments Goals, reforming academic career evaluation, and promoting sustainable development projects. European universities should integrate green policies into their curricula, develop sustainability courses and support circular economy.

Keywords: Sustainable Development Goals; Just Transition; European Green Deal.

How to cite: Nikolaidou, K.; Pavlidou, S.; Karagiannis, I. and Topaloglou, L. (2024) Exploring partnerships between universities, industry and governments to integrate Sustainable Development Goals. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 202-210.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The impact of climate change has undeniably posed substantial challenges for both industrialised and developing countries. The adoption of strategies to tackle this issue, such as the implementation of legislation to decrease CO_2 emissions and the achievement of the Sustainable Development Goals at the global, national, and local levels, have become crucial benchmarks for decision-making across multiple sectors. The European Green Deal, in conjunction with the United Nations' Sustainable Development Goals, are the primary objectives of the policies adopted to transform the EU into a modern, resource-efficient, and competitive economy (Mentes, 2023).

The European Commission highlights the importance of ensuring a fair and inclusive transition towards a carbon-neutral economy. Jenkins et al. (2016) and Sovacool and Dworkin (2015) define "energy justice" as the goal of achieving equity in the global energy system by taking into account the social, economic, environmental, and political effects of participation, whereas "just energy transition" refers to the process of achieving such equity while "moving towards a post-carbon society" (McCauley and Heffron, 2018). This entails prioritizing the well-being of individuals and addressing the specific challenges faced by regions, industries, and workers. The Commission also recognizes that a just transition is crucial for minimizing resistance to necessary changes and ensuring the political viability of the transition. (Strambo, 2020). However the transition to a low-carbon economy is a complex and multifaceted process that involves significant advantages and potential negative consequences. Thus, in order to achieve success in such a intricate phenomenon, the involvement of all four components of the quadruple helix is necessary (Topaloglou and Ioannidis, 2022). While acknowledging the importance of civil society engagement, it is crucial to highlight the significance of collaboration between universities, industries and policy makers, utilising their unique knowledge and resources to provide the most productive setting for innovative and just strategies towards sustainability. According to UNESCO's guidelines, prioritizing education is crucial for promoting sustainable development and achieving the sustainable development goals (SDGs) (UNESCO, 2017). To effectively address the Sustainable Development Goals (SDGs) pertaining to affordable and clean energy (Goal 7), decent work and economic growth (Goal 8), industry, innovation, and infrastructure (Goal 9), reduced inequalities (Goal 10), climate action (Goal 13), and the assessment mechanisms for investments supporting these objectives (Goal 17) in regions undergoing a just energy transition, it is crucial to involve and exchange knowledge among all four components of the quadruple helix.

Over the past decade universities have undergone a significant transformation in their roles. They now have an important part to play in not only educating the future workforce on green jobs, but also in conducting advanced research, becoming incubators for sustainable business

BY-NC-SA 2024, Editorial Universitat Politècnica de València

development, promoting clean energy technologies and innovation,establishing spin off companies and facilitating policy making. Higher education institutions have the responsibility of nurturing the future leaders in sustainability. Moreover they play a crucial role in driving important initiatives at the local, regional, and global levels, and are indispensable in achieving the goals outlined in the Sustainable Development Goals (Franco et al., 2019).Owens (2017) identifies two crucial factors that determine the influence of higher education on SDGs. 1) Collaborations between higher education institutions in the same region and 2) the ability to obtain money for research from public sources. Both these factors highlight the importance of the collaboration between institutions, the business community, and governments.

2. Interactions between universities and industries

The relationship and interactions between industry and the university community encompass a broad spectrum of activities as the institutions have evolved beyond their initially limited educational scope. The universities play a crucial role in the education and training of future human resources and scientists who will be employed in different fields of the industry, and additionally enhancing skills and providing retraining opportunities for the existing workforce through postgraduate study programmes and specialised training programmes for employees. Improving the expertise and skills of the workforce in the European industry is crucial for the advancement of innovative environmentally friendly technologies, ultimately contributing to the achievement of the Sustainable Development Goals. This is particularly important in regions that have traditionally depended on fossil fuels for their economies.

In recent decades, educational institutions worldwide have been transforming into "entrepreneurial institutions," by creating spin offs and deviating from their typical educational role.Furthermore the curriculums are including an increasingly environmentally conscious approach to disseminate innovative clean technologies to companies by conducting cutting-edge research and fostering the development of an ecological mindset inside and outside their campuses.

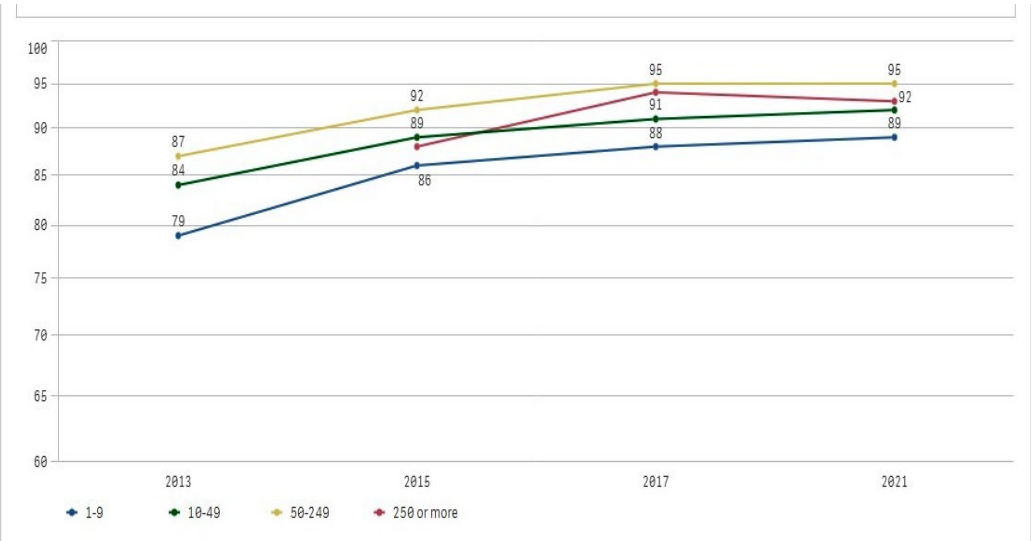
Collaborating with a cutting-edge industry group that prioritizes circularity, resilience, and regeneration could create an environment for European universities to expedite the process of sharing and spreading new knowledge, such as academic research. This partnership could also facilitate the reform of education at all levels (undergraduate, graduate, and lifelong learning) and encourage the development of strategic innovation portfolios. Enhancing public-private partnerships to expedite industrial transformation and collaboration in sustainable practices could incentivize European universities to become more effective hubs of innovation. This would involve not only commercializing research through technology transfer and licensing offices, but also revitalizing education by updating its content, form,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

and reach. Additionally, universities would engage in co-creation and novel forms of interaction with small and medium-sized enterprises, industrial clusters, and society. They would also serve as 'living labs' by testing and acquiring new solutions (European Commission, 2021).To achieve Europe's goal of climate neutrality, the sustainable transformation of industry necessitates the implementation of green technologies that preserve resources and have a minimal environmental impact. Numerous business sectors have already acknowledged and accepted the significance of transforming into a new sustainable model, and they are now in the process of putting this transformation into action by applying the European standards for the execution of the policies arising from the European Green Deal.

In 2021, a significant majority of firms, ranging from 90% to 95% across all sizes, reported implementing strategies to enhance energy efficiency. Additionally, between 31% and 38% of small and medium-sized organizations (SMEs) and 46% of big enterprises indicated their provision of environmentally friendly products or services. Over 40% of large corporations have reported engaging in industrial symbiosis by selling their own leftovers and garbage to other industries. The source of this information is the European Commission, in the year 2022(Figures 1 &2).

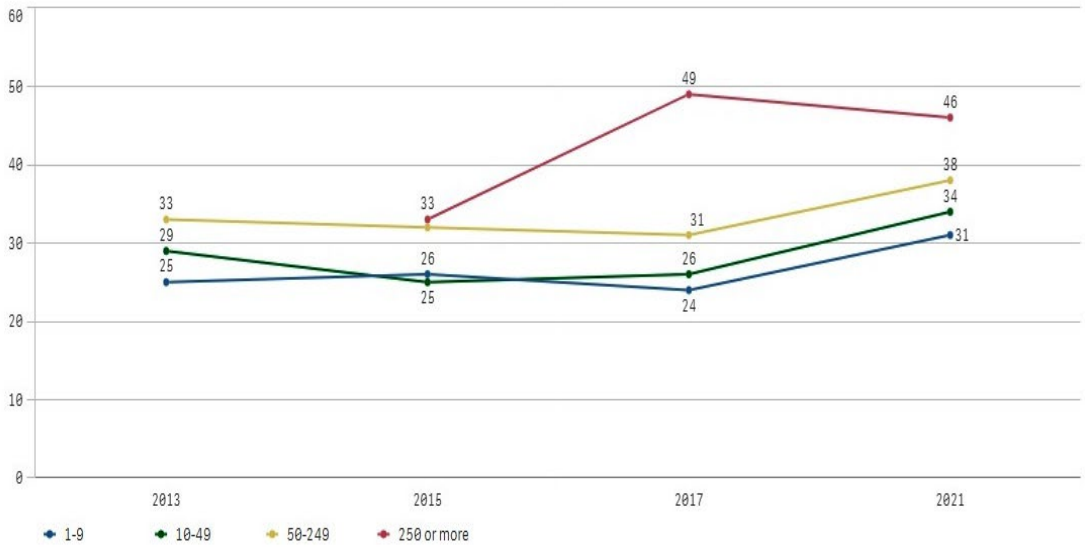
Fig. 1 - Share of SMEs that they were taking at least one resource efficiency action



Source: European Commission, Eurobarometer on SMEs, green markets and resource efficiency, 2021.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 - Offering green products or services (by company size)



Source: European Commission, Eurobarometer on SMEs, green markets and resource efficiency, 2021.

3. The role of the universities in policy-making

Universities play a crucial role in promoting a deep understanding of the complex dynamics and obstacles involved in achieving sustainable and equitable energy transitions. Furthermore they provide valuable policy recommendations and practical insights that can have a positive influence on the development and implementation of sustainability and justice-oriented policies and actions. In addition, universities contribute to advancing knowledge in the areas of sustainability, energy transition, and Sustainable Development Goals (SDGs), thereby encouraging further research and academic discussions and also guiding the formulation of policies and action plans aimed at localizing and interpreting the Sustainable Development Goals especially in areas facing the challenges of just energy transitions.

According to the University Industry Innovation Network (UIIN, 2023), the close proximity of universities to government and policymakers is crucial for the development of policies based on research. As stated by the European University Association (2022), policymakers should collaborate with universities to create and execute innovative ideas regarding sustainable well-being. This is crucial for facilitating a comprehensive transition. Additionally, policies and funding programs should sufficiently support interdisciplinary research and education, making them essential drivers of Europe's sustainability goals. It is indisputable that incorporating evidence and assessment into the policymaking process is essential to achieving success, policy decisions need to be objective and must be driven by the requirements of the nation or the region. To ensure the success of the energy transition project, it is of the utmost importance to either utilise existing evidence to support policy

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

development or to conduct new research to support the design and assessment of strategies. This is because the effective formulation of strategic plans through the use of measurable evaluation mechanisms for investment development is a key factor for achieving success. Davies (1999) defines evidence-based policy-making as a systematic approach that prioritizes the utilization of the most reliable and relevant evidence in order to inform decision-making on policies, programs, and initiatives.

However, it is important to note that this is not an one way relationship. Governments also have the capacity to provide financial and technical support to universities, enabling them to implement sustainable development initiatives and projects. Major EU funds have been allocated to the green economy in order to fulfil the obligations arising from the European Green Deal for the purpose of transitioning the economies depending on of fossil fuels, the skilling, upskilling and retraining of human resources, the restoration of former mine lands, the support of businesses in transition regions, the creation of support mechanisms and observatories of the transition, the promotion of innovation and new green technologies.

The European Commission plans to construct the European Higher Education Sector Observatory in the near future, as part of its technical assistance mechanisms. (European Commission, 2022) The goal of the platform is to consolidate EU data and capabilities into a unified system, facilitating the monitoring of the execution of the European Strategy for Universities and providing proof of the progress of institutional reform across the EU. One of the key goals of the European Strategy for Universities is to enhance universities as agents of change in the dual green and digital transformations.

4. Research methodology

In the framework of the ERASMUS project, entitled "Embedding EU Green Deal and Just Transition in Teaching and Learning-JUST4ALL," with the objective of meeting the need of promoting EU Green policies and Just Transition through teaching and learning along with promoting this context to local/regional/national/supranational stakeholders,a total of 30 semi-structured interviews with local stakeholders who actively participate in the implementation of EU green policies have been conducted in each of the six countries that are partners in the project. These countries are Bulgaria, France, Greece, Spain, Cyprus, and Serbia, all of them include regions that are undergoing just energy transitions. Subsequently, the data search scope was extended to include the other member states of the European Union to ensure the policy suggestions' applicability across all nations within the EU.The interviews focused on the quadruple helix, aiming to capture the participants' viewpoints and concepts.

Research questions were organized in five thematic units where the first theme was related to European green policies, the second theme related to Just Transition - Sustainable

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Development, the third theme related to the relationship between government and universities with regards to EU green policies, the fourth theme related to the relationship between civil society and universities about EU green policies and finally the fifth theme focused on the relationship between industry and universities towards EU green policies.

The interviews were conducted in the participants' native language to promote the gathering of more comprehensive responses and to enhance their freedom of expression. Subsequently, the interviews were translated into English for editing purposes, while the policy briefs were initially created in English and later translated into the native language of each partner (JUST4ALL , 2024).

5. Conclusions and Findings

According to the JUST4ALL project (JUST4ALL, 2024) the following conclusions emerged from the research:

Spain, France, Greece, Cyprus, Bulgaria, and Serbia show favorable government-university collaboration in research, innovation, sustainability, and green policies. French universities use financial support to promote European green policies, while Greek universities are public and funded by the central government. Cyprus' collaboration varies, while Bulgaria lacks government-university interaction and has low green policy agreement among stakeholders. Serbia's government-university interactions on green policies are limited due to frequent strategy changes.

Universities and industries have multiple collaborations, mainly in human resources training and student internships. However, there is little interconnection between local colleges and industries, and innovation efforts have been fragmented. The construction and building industry is identified as an appropriate sector for future collaboration to tackle climate change.

6. Recommendations

The following recommendations were derived from the analysis of data primarily obtained from countries participating in the JUST4ALL project (JUST4ALL, 2024), as well as from other European Union Member States:

To enhance collaboration between universities and governments, it is essential to augment financing, synchronize research with policy requirements, and strengthen the connections between academia and government to ensure efficient policy implementation. Policymakers should prioritize interdisciplinary research and education for Europe's sustainability goals. A combined approach should enhance Horizon Europe and Erasmus+, incorporating innovative techniques like challenge-based learning and living labs. Joint efforts with Member States

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

should reform academic career evaluation. Universities should work with policy-makers to introduce sustainable well-being concepts. The EU should promote strong alliances between the global North and South, encourage nationwide initiatives, and support higher education climate leaders. The EU should also promote green transition skills, promote 'Green Villages', monitor environmental initiatives, and support universities in their sustainability efforts.

The study of European universities reveals recommendations for integrating green policies into their curricula, teaching processes, and outreach activities. These include integrating green policies into curricula, developing sustainability courses, developing distance learning programs, exploring new economic orientations and business ideas, increasing R&D spending, supporting the circular economy, becoming "entrepreneurial universities," and developing relevant training and upskilling programs to support the workforce in the energy transition and shape new production and consumption patterns. Funding and advanced tools are necessary to assess universities' contribution to the diffusion of European green policies.

Acknowledgements

Funding has been received for the development of this paper by Erasmus+ KA220-HED - Cooperation partnerships in higher education, within the context of the project "Embedding EU Green Deal and Just Transition in Teaching and Learning -Just4All" with Project Reference: 2022-1-BG01-KA220-HED-000087487.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Davies, P. (1999). What is evidence-based education?. British journal of educational studies, 47(2), 108-121.

European Commission, (2022). Communication from the commission on a European strategy for universities. Retrieved from: https://education.ec.europa.eu/sites/default/files/2022-01/communication-european-strategy-for-universities-graphic-version.pdf

European Commission, Directorate-General for Research and Innovation, Renda, A., Schwaag Serger, S., Tataj, D. et al., Industry 5.0, a transformative vision for Europe – Governing systemic transformations towards a sustainable industry, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2777/17322

European University Association, (2022). A university vision for the European Green Deal.

Franco, I., Saito, O., Vaughter, P., Whereat, J., Kanie, N., & Takemoto, K. (2019). Higher education for sustainable development: Actioning the global goals in policy, curriculum and practice. Sustainability Science, 14, 1621-1642.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. Energy research & social science, 11, 174-182. doi:10.1016/j.erss.2015.10.004.

Just4All, 2024, "Embedding EU Green Deal and Just Transition in Teaching and Learning", Policy Paper, Erasmus+ KA220 (2023-2025).

McCauley, D., & Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. Energy policy, 119, 1-7. doi:10.1016/j.enpol.2018.04.014.

Mentes, M. (2023). Sustainable development economy and the development of green economy in the European Union. *Energy, Sustainability and Society*, *13*(1), 32.

Owens, T. L. (2017). Higher education in the sustainable development goals framework. European Journal of Education, 52(4), 414-420.

Sovacool, B. K., & Dworkin, M. H. (2015). Energy justice: Conceptual insights and practical applications. Applied energy, 142, 435-444. doi:10.1016/j.apenergy.2015.01.002.

Strambo, C. (2020). Just transition and the geopolitics of decarbonization in the EU. Stockholm Environment Institute Policy Brief.

Topaloglou, L., & Ioannidis, L. (2022). From transition management towards just transition and place-based governance. The case of Western Macedonia in Greece. https://doi.org/10.7341/20221832

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2017). Education for sustainable development goals: Learning objectives.

University Industry Innovation Network (UIIN), (2023). The Role of Universities in the Sustainability Transition. Retrieved from https://www.uiin.org/2023/03/09/role-of-universities-in-sustainability/

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

The role of universities and civil society's engagement in fostering entrepreneurship in energy transition and climate change.

Sofia Pavlidou[a], Konstantinia Nikolaidou[b], Lefteris Topaloglou[b] and Rafaella-Eleni P. Sotiropoulou [a]

[a] Department of Mechanical Engineering, University of Western Macedonia, Greece
[b] Department of Chemical Engineering, University of Western Macedonia, Greece

Abstract

The European Green Deal mandates a shift towards sustainable solutions to decrease CO_2 emissions in order to combat climate change. This study examines the role that universities and society can play in promoting green entrepreneurial development in energy transition areas. Universities are conduits of information, incorporating sustainable energy into their curriculum and partnering with enterprises for research and production. They also incorporate entrepreneurship through spin-off firms and hubs. The empirical section of the paper involves a survey and policy brief on the role of universities in EU green policies within the context of the Erasmus+ project "Embedding EU Green Deal and Just Transition in Teaching and Learning - Just4All". The study sample includes stakeholders from six partnering countries, Bulgaria, France, Greece, Spain,Cyprus and Serbia. The outcome is a set of recommendations to enhance connections between universities and society, as well as emphasizing the crucial involvement of both entities in the energy transition processes.

Keywords: energy transition; climate change; green entrepreneurship; SDGs

How to cite: Pavlidou, S.; Nikolaidou, K.; Topaloglou, R. and Sotiropoulou, R.E.P. (2024) The role of universities and civil society's engagement in fostering entrepreneurship in energy transition and climate change. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 211-219.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

As societal expectations for environmental standards increase, the environment has emerged as a pivotal and finite asset for both the economy and society. Economic activities exert pressure on the environment, while environmental shifts reciprocally affect the economy.The need to transition to environmentally friendly and sustainable energy sources has been driven by both the global reaction to climate change and the imperative to reduce dependence on fossil fuels (Karduri and Ananth, 2023).

Given these circumstances, regions heavily reliant on the production of lignite and coal are now confronted with the need of thoroughly reorganising their economic strategy. Achieving a just energy transition, demands the establishment of new land usage, optimal investment decisions, and the formulation of an inclusive, environmentally sustainable and just development strategy (Akpan and Olanrewaju, 2023). To successfully complete this task, it is necessary to identify, analyse, and evaluate the diverse range of economic, social, and environmental issues that impact a just transition.

Therefore, active collaboration between academic institutions and local authorities is essential. By leveraging their specialised knowledge and expertise, institutions may successfully aid authorities in formulating regional development plans and strategies. Nevertheless, it is important not to overlook the involvement of civil society throughout this process. It is well recognised that for any plan to achieve utter success, it is necessary to encourage society to actively participate in the consultation process and embrace the approach (Topaloglou et al, 2023).

Citing Topaloglou and Ioannidis (2022), recent developments in business, technology, demographics, and climate change have drawn attention to the need for a networked world with an increasing societal complexity. Government, industry, academia, civil society organisations, and individuals establish official and informal networks where their opinions may differ or align. Instead of policy alone, policymakers should incorporate creative techniques to learning, engagement, integration, and experimentation at the societal level (Loorbach, 2010).

2. Green Entrepreneurship

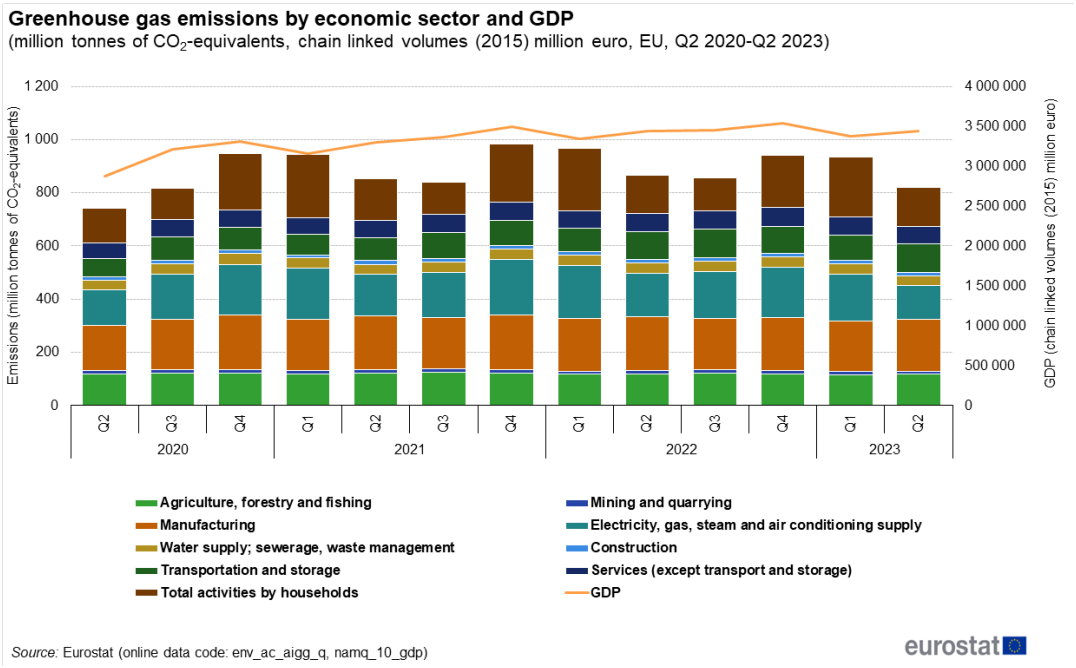
As a means to tackle climate change and meet the Sustainable Developments Goals (SDGs) set by the United Nations in 2015, the European Parliament has approved the European Climate Law, which increases the EU's goal to reducing net greenhouse gas emissions by at least 55% by 2030 (compared to the present 40%) and enforces the legal obligation of achieving climate neutrality by 2050.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

It is evident that carbon dioxide emissions encompass numerous sectors, with the bulk of them being related to economic activity.Hence, we understand the significance of transitioning the manufacturing model to a sustainable and environmentally friendly approach that is in addition economically advantageous.

The advancement and progression of the endeavour to accomplish the aforementioned goals is carefully observed via regular reports and is shown in diagrams, like the one depicted below (Figure 1):

Fig. 1 - Greenhouse gas emissions by economic sector and GDP

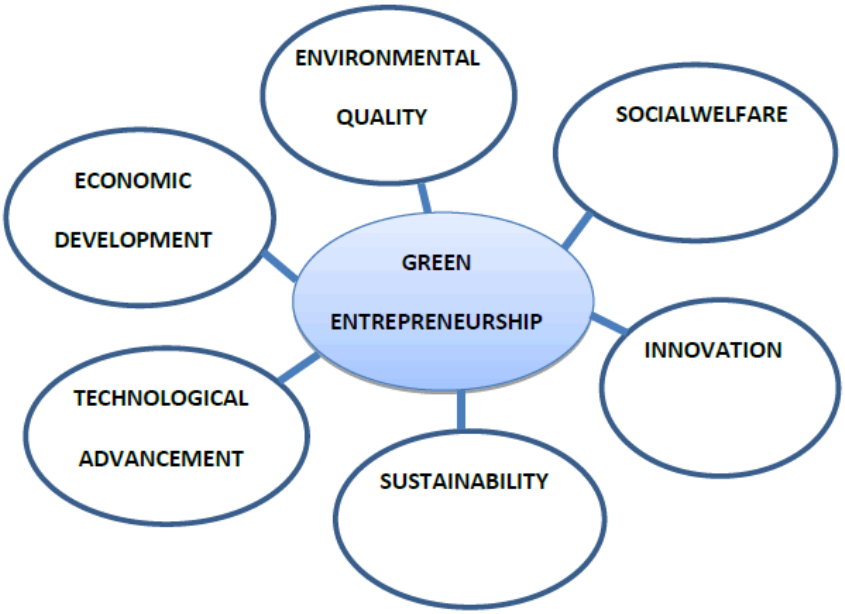


Source: Eurostat

Environmental entrepreneurship has emerged as a crucial element in attaining sustainable development objectives. Entrepreneurs in developed nations are experiencing a shift in their perspective, particularly in relation to their business practices, as they now take into consideration the ecological consequences. (Gu and Zheng, 2021).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 - Components Of Green Entrepreneurship



Source: Haldar and Dutta , 2017

According to Haldar and Dutta (2017) the term environmental or green entrepreneurship refers to a profitable entrepreneurship that prioritises environmental sustainability and generates social benefits. In other words, it simultaneously integrates economic, environmental, and social aims. This term refers to a business that is both economically and socially engaged and plays a significant part in turning ideas into tangible outcomes. It does so by undertaking business opportunities that include a certain degree of risk and innovative thinking, which in turn address and resolve environmental issues in society while also improving competitiveness(Figure 2).

3. The contribution of universities to green entrepreneurship

Without the slightest doubt, universities are highly appropriate venues for spreading European green policies derived from the Green Deal. This is because they educate and prepare the next generation of professionals and entrepreneurs, collaborate with governmental bodies, establish their own entities, and actively contribute to fostering business innovation through partnerships, incubators, and research endeavors.

As the European University Association (Kozirog et al.,2022) highlights, Europe must effectively harness the potential of its innovative ecosystems to drive the transformative processes of digitalization and environmental sustainability. Potential solutions for these difficulties may be identified, but they can only arise by utilising the resources and competencies of all parties involved, including of course the academic community.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Opting for entrepreneurship education is crucial for attaining progress and overcoming the many economic and social obstacles confronting the majority of nations worldwide. Its primary objective is to enhance the competencies and aptitudes of individuals, enabling them to actively engage in business and become a valuable asset. Entrepreneurship education seeks to provide students with the skills and knowledge necessary to effectively manage their own businesses, using a comprehensive curriculum or integrated programme outside of the mere dissemination of information (Aithal and Rao, 2016). Universities exert a substantial impact on regional economic prosperity by attracting external investments and significantly contributing to wealth generation. Moreover, they have transitioned from being solely educational institutions to adopting an entrepreneurial role by fostering the creation of spin-offs and serving as business incubators.

Nevertheless, in the present time, it is insufficient to possess the knowledge of establishing and managing a prosperous business venture. It is imperative to also adopt environmentally friendly and sustainable practices to adhere to European regulations aimed at minimising carbon dioxide emissions and reducing reliance on mineral resources. University education significantly contributes to the enhancement of scientific knowledge, the cultivation of skills, and the fostering of responsible attitudes and behaviours towards the future. Focusing on cultivating skills for green entrepreneurship at university is a fundamental aspect of promoting sustainable development.(Anghel and Anghel, 2022).

Universities have taken action by establishing new departments and curricula specifically focused on sustainability. Numerous business schools have established institutes and funded chairs. Academics are diligently exploring the concept of business sustainability, with a growing number of papers being published in prominent management journals. Furthermore, scholarly publications in fields like law, finance, and political science have been actively contributing to the body of knowledge on corporate sustainability. This indicates that corporate sustainability is a study topic that spans several disciplines, but it may not necessarily include the integration of different disciplines.

4. Civil society's participation in green transition and entrepreneurship

In the framework of society, the attributes of green entrepreneurship are defined within the context of sustainable development. Green entrepreneurship appears in various forms and facets within a society that demonstrates a substantial number of individuals seeking to engage in this type of entrepreneurial activity. The ideas, beliefs, and opinions of these individuals or civil organizations are situated within the context of prevailing issues, and their actions are driven by the objective of fostering an improved and more sustainable environment for future generations (Anghel and Anghel, 2022). The absence of social acceptance, encompassing socio-political acceptance, community acceptance, and market

BY-NC-SA 2024, Editorial Universitat Politècnica de València

acceptance, can hinder the effective implementation of the energy transition. It is wider known that without the awareness, acceptance, and active engagement of society, achieving success in the energy transition becomes unattainable.

As Strabo (2020) stresses many municipalities and regions impacted by energy transitions suffer from a lack of socio-economic resilience due to previous financial crises, globalisation, or severe environmental consequences due to past industrial and mining activities.Even transitions that are considered "successful" might hide and even increase disparities among the most marginalised parts of society and less qualified employees. In order to prevent such results, the implementation of just transition policies ought to take action as part of a holistic social policy framework that addresses ongoing socioeconomic inequalities across multiple facets.

5. JUST4ALL project's findings

Within the contex of the Erasmus "Embedding EU Green Deal and Just Transition in Teaching and Learning-JUST4ALL" project, government officials, industry, civil society and universities were studied through 30 civil society-university collaboration surveys from the six collaborating countries: Greece, Cyprus, Bulgaria, Serbia, Spain, and France. The research participants were interviewed in their native language to stimulate fuller replies and freedom of expression. Semi-structured interviews were used to assist in extracting participants' experiences, opinions, ideas, expectations, beliefs, and emotions. The interview questions included five topics. European green policies were the first topic,the second subject was Just Transition-Sustainable Development,the third subject was government-university interactions on EU green policy,the fourth subject was civil society-university relations on EU green policy and the fifth subject is industry-university partnerships towards EU green policies. In the policy brief analysing survey responses on civil society-university interactions and EU green policies, most respondents acknowledged universities' efforts to raise environmental awareness, educate, and collaborate with civil society. Universities have a positive impact, but their civic involvement can be improved.

Greek universities must provide teaching and outreach services. Certain universities engage in partnerships with local organisations to preserve the environment and biodiversity. Additionally, their academic programmes aim to educate businesses and communities about environmental issues. Cyprus respondents stated that certain universities work on important environmental issues like waste management and the Sustainability Charter, while others take superficial actions. Collaboration requires centralised structures like a parallel parliament, information sharing, and skilled human resource investment.

Bulgarian citizens have grown increasingly ecologically conscious in the last decade. Corporate criticism and social division have met calls for higher education to join the green

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

revolution. Civil society-university interactions should be promoted via joint efforts regardless of objections. Green policies and environmental culture have minimal impact on civil society in Serbia due to limited information dissemination and economic constraints related to lack of funding.

Spain and France promote university-civil society partnerships highly. Civic society and academics encourage Spanish government to adopt EU green policies. Sustainability campaigns and university and government accountability by civil society can change realities. This relationship may be enhanced via public engagement, cooperative projects, and information exchange to encourage sustainable habits and policies. However, French university-civil society EU green policy partnership is questionable. Others applaud active involvement, while others lack awareness. More funding and commitment from academic institutions and external stakeholders, public awareness, and student empowerment as environmental ambassadors are required to expand these relationships and improve environmental culture(JUST4ALL, 2024).

6. Conclusion and suggestions

The JUST4ALL project has culminated in six fundamental recommendations to bolster sustainability endeavors. Firstly, it underscores the significance of enhancing and broadening connections among scholars, civil society, and enterprises to promote cooperation in sustainability education and remedies. Universities have a vital role to play in this matter and should aggressively establish connections and provide assistance to excluded groups. Furthermore, it proposes that university policy should actively encourage transdisciplinary research, innovation, and scholarship throughout academic careers. Universities are urged to take a more proactive approach in providing scientific guidance, engaging in environmentally friendly activities, mitigating climate change, and promoting social well-being. Additionally, they should strive to increase their involvement in shaping policies, fostering innovation, and collaborating with industries to promote sustainability.

Furthermore, the project supports the advancement of lifelong environmental education across multiple sectors. This encompasses increasing awareness of the repercussions of not attaining sustainability and elucidating how individuals and communities may actively contribute to this objective. Furthermore, it is necessary to create a durable environmental framework that is backed by political support for the population. This framework aims to grant citizens and community groups substantial decision-making power and guarantee that they receive consistent and comprehensive information.

Finally, the study suggests creating a worldwide baseline for Sustainable Development Goals (SDG) in higher education. The proposed benchmarking system aims to assess the extent to which institutions contribute to the Sustainable Development Goals (SDGs) through their

BY-NC-SA 2024, Editorial Universitat Politècnica de València

research, teaching, and community engagement efforts. This alternative strategy, which differs from a hierarchical ranking system, would incentivize schools that successfully accomplish many Sustainable Development Goals (SDGs). As a result, it would promote a more cooperative and comprehensive approach to sustainability in higher education. (JUST4ALL, 2024).

Acknowledgements

Funding has been received for the development of this paper by Erasmus+ KA220-HED - Cooperation partnerships in higher education, within the context of the project "Embedding EU Green Deal and Just Transition in Teaching and Learning -Just4All" with Project Reference: 2022-1-BG01-KA220-HED-000087487.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Aithal, P. S., & Rao, P. (2016). Green education concepts & strategies in higher education model. International Journal of Scientific Research and Modern Education (IJSRME) ISSN (Online), 2455-563. Available at SSRN: https://ssrn.com/abstract=2822990

Akpan, J., & Olanrewaju, O. (2023). Sustainable energy development: History and recent advances. *Energies*, *16*(20), 7049.

Anghel, G. A., & Anghel, M. A. (2022). Green Entrepreneurship among Students—Social and Behavioral Motivation. Sustainability, 14(14), 8730. https://doi.org/10.3390/su14148730

Gu, W., & Zheng, X. (2021). An empirical study on the impact of sustainable entrepreneurship: Based on the environmental Kuznets model. Journal of business research, 123, 613-624.

Haldar, S., & Dutta, I. (2017). Green Entrepreneurship in Theory and Practice: Insights from The Indian Markets. International Journal of Scientific Research and Development, 1(5), 706-721.

Just4All, 2024, "Embedding EU Green Deal and Just Transition in Teaching and Learning", Policy Paper, Erasmus+ KA220 (2023-2025).

Karduri, R. K. R., & Ananth, C. (2023). The Role of Policy in Accelerating the Energy Transition. *This paper has been published in International Journal of Advanced Research In Basic Engineering Sciences and Technology (IJARBEST) DOI*, *10*.

Kozirog, K., Lucaci, S.M. and Berghmans, S. (2022). Universities as key drivers of sustainable innovation ecosystems. Results of the EUA survey on universities and innovation. European University Association.

Loorbach, D. (2010). Transition management for sustainable development: A prescriptive, complexity-based governance framework. Governance, 23(1), 161–183. https://doi.org/10.1111/J.1468-0491.2009.01471.X

2024, Editorial Universitat Politècnica de València BY-NC-SA

Strambo, C. (2020). Just transition and the geopolitics of decarbonization in the EU. Stockholm Environment Institute Policy Brief.

Topaloglou, L., & Ioannidis, L. (2022). From transition management towards just transition and place-based governance. The case of Western Macedonia in Greece. https://doi.org/10.7341/20221832

Topaloglou, L., Kouskoura, A., Janikowska, O., Grozeva, R., Nikolaidou, K., Karagiannis, I., & Kulczycka, J. (2023). Stakeholder Involvement in Just Transition Process: Myth or Reality?. *Available at SSRN 4510270*.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Enabling the flow of knowledge for the Energy and Hydrogen Transition

Marsha Wagner[a], Jan Geurts van Kessel[b] and Rob de Jeu[c]

[a] Energy Innovation NL[1] / GroenvermogenNL[2], The Netherlands
[b] GroenvermogenNL / HAN University of Applied Sciences, The Netherlands
[c] Energy Innovation NL, The Netherlands

Abstract

With this paper, we describe the Dutch strategy on skills valorisation - based on successful approaches of Energy Innovation NL (EINL) and GroenvermogenNL (GVNL) for the energy and hydrogen transition. To achieve success in these transition, substantial new knowledge is required. To apply this new knowledge in the labour market, research and innovation must increasingly intertwine with regional learning communities (LC) where innovation, learning, and work are harmonised. This way, skill valorisation will be realised: valorising new knowledge from research and innovations through developing professionals', students', and teachers' skills and practice-oriented research through public-private partnerships. We argue that skills valorisation is an imporant part of the knowledge and innovation policy and a strong collaboration between Universities of Applied Sciences and Vocational Institutions are needed to strengthen education and research. The next step is the recognition of acquired skills through the LC approach. The goal of this solution is to bring together several effective approaches: the development of a national approach to enable individual learning pathways towards skills profiles, across the different educational partners and regional public-private campuses.

Keywords: Human Capital; Learning Communities; Skills Valorisation; Hydrogen.

[1] https://topsectorenergie.nl/en/

[2] https://groenvermogennl.org/en/, this is one of the programs of the National Growth Fund in the Netherlands: https://www.nationaalgroeifonds.nl

How to cite: Wagner, M.; Geurts van Kessel, J. and de Jeu, R. (2024) Enabling the flow of knowledge for the Energy and Hydrogen Transition. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 220-229. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Introduction

With this paper, we describe the Dutch strategy on skills development - based on successful learning community approach of Energy Innovation NL (EINL) and GroenvermogenNL (GVNL) for the energy and hydrogen transition. Predicting the future is impossible. We are in an era of 'shocks.' Each shock has a different cause (credit crisis, COVID-19, war in Ukraine, war in Gaza, etc) and consequence (economic brakes applied, an overheating economy, job loss, energy poverty, and high inflation). Not only does addressing the immediate consequences take priority, but so does organising ourselves, learning from each other, innovate the educational system in relation to research, and enhancing collaboration within the European Union to better cope with these and future shocks.

The hypothesis of this paper is that developing and implementing the learning community approach will enable skills valorisation. This paper provides an analysis of literature and case studies and presents the main results. The final section describes the conclusions of the analysis.

Context

Energy Innovation NL (EINL) and GroenvermogenNL (GVNL) are two of the driving forces behind the innovations needed for the transition to an affordable, reliable, and sustainable energy system for the Netherlands. The success of the energy and hydrogen transition requires significant new knowledge e.g. for new hydrogen technologies or development of new safety standards. To apply this new knowledge in the labour market, research and innovation must increasingly intertwine with regional learning communities[3] (LCs) (Topsectors, 2017], where innovation, learning, and work are harmonised (Case study" The Green Village). This way, skills valorisation will be realised: valorising new knowledge from research and innovations through developing professionals', students', and teachers' skills and practice-oriented research through public-private partnerships (Ministerie van Economische Zaken en Klimaat, 2023). A more in-depth conceptual framework of learning communities is given by Schipper et al (2023).

Case study: The Green Village (West region)

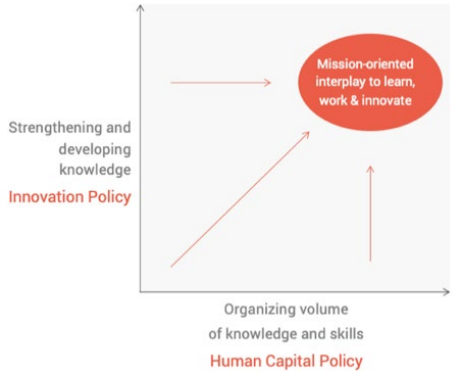
A sustainable future calls for innovative ideas and new practical methods and techniques. At The Green Village, knowledge and educational institutions, businesses, governments, and citizens explore, experiment, validate, and demonstrate their sustainable innovations. The Green Village is a regulatory-light "outdoor laboratory" on the TU Delft Campus focusing on the built environment, where testing can occur at the neighbourhood, street, and building levels. With access to the innovation ecosystem of TU Delft, science is literally around the corner. It is a place where people live, work, and learn.

[3] https://youtu.be/vfDd2LxX0yA?feature=shared and https://youtu.be/umzeUzGak9s?feature=shared for more information on Learning Communities.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

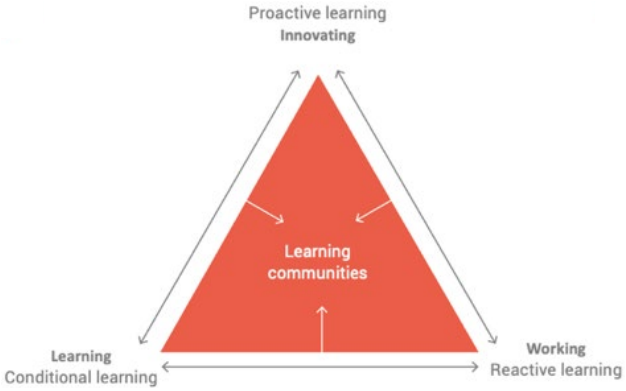
This strategy originated since innovation seemed to exist in a parallel universe, disconnected from the challenges associated with skills development. Research shows that if you don't translate knowledge and innovation development into skills, the employment opportunities that arise from it usually migrate (Diodato, D., 2015). There is a proven causal relation between a robust cognitive embedding in the region creating opportunities (for smaller emerging clusters that offer limited employment) and strengths (for larger existing clusters that provide substantial employment) of economic clusters. But if skills are a critical factor in economic growth coming from new knowledge and skills, why is skill development not (always) an integral part of research and innovation? (Giessen, A., 2017). The 'learning communities' strategy has been developed in the Netherlands (Energy Innovation NL, 2023). This approach aims to foster synergy between knowledge and innovation policy and human capital policy (Figure 1). The implementation of this synergy occurs within so-called learning communities (Figure 2).

Fig. 1 – Synergy between Innovation- and human capital policy.



Source: Qeam (2019)

Fig. 2 – Converging innovating, learning and and working.



Source: Topsectors (2017)

In the Netherlands, 118 LCs are emerged in the last six years and are still growing in numbers. LCs inhibit two main concepts: the three functions of lifelong learning (informal, formal, and proactive learning) and the definition of knowledge (implicit and explicit knowledge). These LCs allow professionals to work on their skills and operate as partners in innovation.

Innovation projects will form a rich breeding ground for developing skills of students and professionals. The recently started program 'Learning Communities System Integration' (Energy Innovation NL, 2024). is built on this concept and works with 'use cases' (The Green Village, 2022) to innovate solutions for system integration within our energy system and as an enabler for the skills development of professionals and students.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Skills Valorisation as part of the knowledge and innovation policy

To implement skills valorisation, EINL and GVNL encourage consortia applicants for R&D- and innovation subsidy calls to seek collaboration with regional learning communities. This fosters cooperation and an approach between companies, researchers from all sectors, students, and (researching) teachers from the entire spectrum of (vocational) education (universities, colleges, and vocational schools). Together, they can develop approaches for each research and innovation project where innovation, learning, and work converge. A learning community will focus around a set of challenges or research objectives i.e. use cases that can be translated into assignments and working packages. Students and professionals can absorb the learnings in the form of new knowledge and skills from these projects. The shared collaboration on these use cases thus facilitates skills valorisation. In this way, EINL and GVNL continuously feed the regional LCs with use cases, which leads to skills development that enables innovations to grow economically.

Case study: Communities for Development (South-East region)

In Communities for Development (CfDs), students and experienced professionals work under the coaching of a researcher on a challenge from the field. The assignment is central to the research group, and an independent assessor assesses the learning outcomes. Using an experienced professional as a 'working leader' ensures the quality of the research outcome and a low threshold with the novice professional (student). In addition to building knowledge that flows back into education, this coach ensures continuity in longer projects involving multiple CfDs. Furthermore, the coach is essential for understanding and filling knowledge gaps (e.g., literature and networks).

The assignments connect innovation, professionalisation, and education in the themes of Molecular Health, Circular Materials, and Sustainable Chemistry. For the Applied Science program, this is a fixed part of the curriculum, but often, students from other academies or knowledge institutions from both within and outside the country also participate as part of a project, minor, or internship. Depending on the assignment, multilevel (university, college, vocational) interdisciplinary CfDs may exist. The assignment takes place where it is best suited. Usually, these are the state-of-the-art facilities of the Chemelot Innovation and Learning Labs at the Brightlands Chemelot Campus.

Simultaneously, they collaborate closely with the Dutch Research Council (NWO) (Dutch Research Council, 2024) to realise and fund research into learning communities. Over the past four years, more than 7.5 million euros have been invested in this type of research. These have been successful researches. An example is "Gas erop!" where research is conducted by the University of Twente and Saxion University of Applied Sciences in collaboration with the institution on vocational education Twente and a network of Small and Medium Enterprises (SMEs) (Applied University Saxion, n.d.). This research shows its value to transfer knowledge to practice.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Case study: Celciushuis (Middle-Region)

Within this Innovation workshop, companies, residents, students, travelers and researchers work together trans-disciplinary on area-specific innovations for a healthy, sustainable new city district. The challenges focused on are location specific problems based on questions from residents or the municipality.

With this Celciushuis Innovation workshop, we work transdisciplinary on area-specific innovations for a healthy, sustainable new city district. This innovation workshop is based in the upcoming Amersfoort city district of Hoefkwartier. The challenges we work on do not start from a technical innovation, but from a location specific problem. These questions usually come from residents or the municipality. The concepts developed are not merely reports, we always strive to create physical prototypes so we can let end users experience the future and provide feedback.

The subprojects of the Innovation workshop deal with three main themes which were identified in the beginning of the practice as most relevant among (future) residents and stakeholders. The themes were cross-referenced with the knowledge and innovation agenda of the Centre of Expertise Smart Sustainable Cities and the political agenda of the municipality. For now, these topics are: 1. Comfortable survival, a house without a safety net, 2. The city as a closed ecosystem, working on closed circles, 3. The creative neighborhood living room, building a community. Using these main topics, a steady stream of manageable subprojects and follow-up paths are generated.

Translation into Education and SMEs

To achieve this, 'professors from universities of applied sciences' and 'practors' from vocational institutions are essential in research consortia.

Glossary. Defintions of 'practor' and professor of 'applied science':

Practor	***Professor of applied science***
Practorates are multidisciplinary teacher teams installed in VET institutes which carry out applied research to explore new professional practices (practoraten.nl, n.d-a). 117 practorates are currently active across 54 VET institutes[4]. The goal of practorates is to stimulate a research mindset within the VET institutes and eventually stimulate innovation in the vocational sector (practorates, n.d-a). A practor is a figurehead, inspirer, and engine of a practorate in a vocational institution. A practor is responsible for developing, applying, and disseminating knowledge within the vocational institution and beyond. Conducting practice-oriented research and professionalising teachers are also essential tasks.	Universities of applied sciences appoint professors of applied science. The core tasks of the professor are related to research, education, and professional practice. A professor is responsible for initiating, developing, and conducting practice-oriented research. In interaction with professional practice and connection with education, the lecturer stimulates knowledge innovation and the professionalisation of teachers. Practice-oriented research at universities of applied sciences links inherently to education. The research aims to enhance the quality of students, align education with current developments in practice, and introduce innovation into the (professional) practice.

[4] Not all institutions on vocational educational have a practorates, as some count several practorates and others count none.

2024, Editorial Universitat Politècnica de València BY-NC-SA

It is their speciality to conduct practice-oriented research and translate it into the education of students and professionals. Together, they play a central role in ensuring success. Furthermore, they are closer to SMEs through practical research and can initiate projects with SMEs to shape knowledge development and valorisation towards SMEs. Special attention is needed to harness vocational education's (unknown) potential. Vocational teachers, students and professionals participating in knowledge development can easily make new knowledge practical through applied research, making it applicable to (SME) companies.

Strong Collaboration between Universities of Applied Sciences and Vocational Institutions

Thus, in a new, challenging approach – using learning communities – to strengthen connections, universities of science, applied sciences and vocational institutions are necessary for education and research. In many regions, universities of science and, applied sciences and vocational institutions have already developed successful and proven approaches for this purpose. These approaches have proven effective and are valuable to research and innovation (see Case study: Greenwise Campus).

> Case study: Greenwise Campus (North-East region)
>
> At the Greenwise Campus, the University of Groningen, NHL Stenden, and Drenthe College collaborate with companies to strengthen the region's innovative capacity and economic strength while retaining talent for the region. This includes regional production of green hydrogen from alternatives to pure water, such as seawater and sewage. Facilities have been built for conducting tests. Companies use the resulting hydrogen as an energy source.

New forms of collaboration like these, integrating skills and knowledge development, can inspire even more concrete new collaborations where the triangle of learning, working, and innovating develops integrally. Each form depends on the context and is designed to achieve optimal regional impact. However, in all these examples, the University of Applied Sciences plays a central role, and there is added value through the involvement of vocational institutions.

Challenges in Vocational Participation in Public-Private Partnerships for knowledge development and innovation

There are still challenges experienced in vocational education participation in public-private partnerships (PPPs) like learning communities. One of these is that vocational institutions are also considered economic entities for their research under the state aid rules, resulting in lower subsidy rates than universities of applied sciences and universities. Additionally, recognising vocational institutions and their PPPs as attractive collaboration partners must catch up (see Case study: Applied Research Team. It is essential to address these challenges

BY-NC-SA 2024, Editorial Universitat Politècnica de València

to improve the participation of vocational institutions and thus increase the added value of the innovation ecosystem.

Case study: Applied Research Team (East region)

The Applied Research Team (ART) works on innovation, with knowledge development, practical application, and knowledge sharing at its core. A research question from the field serves as the starting point, with close communication with the clients. Students play an active role at various levels (university, college, vocational). In addition to researchers, the team includes passionate students who make a crucial contribution. Together with the Supervisory Board, the aim is to maximise the impact of the developed knowledge in the research. This advisory board comprises experienced and knowledgeable professionals from vocational education, academia and industry. Innovation, work, and learning go hand in hand, forming a dynamic mix. The mission goes beyond research: the team develops tools and materials to transfer knowledge to teachers and professionals, contributing to a better future.

The Applied Research Team was initiated by the Sustainable Electrical Energy Centre of Expertise (SEECE). SEECE is a public-private partnership that focuses on developing an affordable, reliable and sustainable energy system. The partners from industry, vocational education and universities of applied sciences developed the Applied Research Team concept as an operational tool to accelerate innovations and its application serving the energy transition. Several ARTs are assigned to projects in heavy-duty equipment and energy hubs for the built environment.

Skills validation

The implementation of the vision described above is well underway in all regions of the Netherlands and for all innovation themes aimed at achieving a sustainable, affordable, and reliable energy system. The next step is the recognition of acquired skills through the LC approach. This is an exciting innovation because there is currently no ready-made solution for this. GVNL will soon launch the program 'Make Hydrogen Work' focusing on this aspect. The program started in 2024 and the first results are expected later this year. It is developing a national solution that will simultaneously further support international and European collaboration. The goal of this solution is to bring together several effective approaches: the development of a national approach to enable individual learning pathways towards skills profiles, across the different educational partners and regional public-private campuses:

1. The foundation for adapting 'Make IT Work' (Make IT work, n.d.). to hydrogen learning pathways will be based on the skill profiles established within the EU that students and professionals need to acquire for the hydrogen economy.
2. Adapting Smart Makers Academy (Smart Makers Academy, 2022) to hydrogen, which aims at SMEs and professionals for orientation and inspiration on digitalisation in smart industry. This academy consists of a vast campus network that supports small and medium-sized enterprises (SMEs) in taking steps toward the smart industry.

2024, Editorial Universitat Politècnica de València BY-NC-SA

3. Utilising the system(s) for micro credentials[5] so that both learning paths and orientations and introductions are recognised in the job market.

This will be an innovative program and can become the prerequisite for organising skills validation for education and lifelong learning in the future.This program leans and makes use of the 'Coordinated approach to Human Capital' which is embraced by the public investment funds in human capital for the energy transition, such as the Just Transition Fund from Europe, and the programs LLO Catalyst and Upscaling PPS Vocational Education (Energy Innovation NL, 2024). The regional liaisons of GVNL initiated and work within the regional ecosystems that arose for the hydrogen economy and. They put the coordinated approach to implementation in their region and integrated this in the regional roadmaps (GroenvermogenNL, 2024).

Concluding

With this abstract, we started describing the Dutch strategy on skills development for a flourishing society. The hypothesis is that developing and implementing the learning community approach will enable skills valorsation. Our conclusions are:

- The implementation of skills valorisation as integral part of policy programs on innovation and research is in its early fase and doesn't have a solid track record yet
- The reseach on Learning communities as vehicle of skills valorisation is successful and has resulted into proven skills development tools for professionals
- SMEs develop themselves through co-creation which helps them to innovate their business and to build the skills of their employees
- The vocational institutions are considered economic entities for their research under the state aid rules; this explains why they participate on a small scale in research and innovation projects
- It requires public private partnership like the provided Case studies to realise synergy between learning, research and innovation in focused programs on energy and hydrogen enables knowledge to flow (education, life long learning)
- For validation of skills developed within LC-programs much more research is required

We aim to have this discussion about these conclusions with multiple countries during the SEED Conference and to learn from others and at the same time share our learnings.

[5] Micro-credentials certify the learning outcomes of short-term learning experiences, for example a short course or training. They offer a flexible, targeted way to help people develop the knowledge, skills and competences they need for their personal and professional development. From: https://education.ec.europa.eu/education-levels/higher-education/micro-credentials

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

No funding has been received for the development of this research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Applied University Saxion (n.d.). *Gas Erop!* Saxion. Retrieved February 5, 2024, from https://www.saxion.nl/onderzoek/meer-onderzoek/employability-transition/gas-erop

Diodato, D., Weterings, A. (2015). The resilience of regional labour markets to economic shocks: Exploring the role of interactions among firms and workers. *Journal of Economic Geography* 15(4): 723–742.

Dutch Research Council (2024, January 1). *Dutch Research Council*. NWO. Retrieved February 5, 2024, from https://www.nwo.nl/en

Energy Innovation NL (2023, October 29). *Vision 2030: 'More with Less'*. Topsector Energie. Retrieved February 5, 2024, from https://topsectorenergie.nl/nl/kennisbank/human-capital-topsectoren-2024-2027/

Energy Innovation NL (2024, January 1). *Learning Communities Systeemintegratie*. Topsector Energie. Retrieved February 5, 2024, from https://topsectorenergie.nl/nl/projecten/learning-communities-systeemintegratie/

Energy Innovation NL (2024, January 1). *Samenhangende aanpak*. Topsector Energie. Retrieved February 5, 2024, from https://topsectorenergie.nl/nl/maak-kennis-met-tse/human-capital-agenda/samenhangende-aanpak/

Giessen, A. (2017). *Spread of innovation THE UNDEREXPOSED SIDE OF INNOVATION POLICY*. AWTI.

GroenvermogenNL (2024, January 1). *PL-2: 'Regional Liaisons and Learning Communities'*. Retrieved February 5, 2024, from https://groenvermogennl.org/en/human-capital-agenda-energy-transition/pl-2-regional-liaisons-and-learning-communities/

Make IT work (n.d.). *Make IT work*. IT Omscholing. Retrieved February 5, 2024, from https://it-omscholing.nl/

Ministerie van Economische Zaken en Klimaat (2023, November 2). *Kennis- en Innovatieconvenant 2024–2027*. Staatscourant van het Koninkrijk der Nederlanden. Retrieved February 5, 2024, from https://zoek.officielebekendmakingen.nl/stcrt-2023-30827.html

Schippers et al (2023, August). Interorganizational Learning: A Conceptualization of Public-Private Learning Communities, *Human Resource Development Review*

Smart Makers Academy (2022, January 1). *Op het juiste spoor naar de toekomst*. Retrieved February 5, 2024, from https://www.smartmakersacademy.nl/

2024, Editorial Universitat Politècnica de València BY-NC-SA

The Green Village (2022, February 24). *Learning Communities Systeemintegratie in Delft*. Retrieved February 5, 2024, from https://www.thegreenvillage.org/learning-community-systeemintegratie-in-delft/

Topsectoren (2017, June 27). *Learning communities - gezamenlijke Topsectoren* [Video]. Youtube. https://www.youtube.com/watch?v=vfDd2LxXoyA

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Broadening horizons, sustainable development in education

Ramón Soria Momparler[a] and David Sornosa Cervera[b]

[a] Departamento de Electrónica, IES El Cabanyal, España
[b] Departamento de Electrónica, IES El Cabanyal, España

Abstract

When we talk about sustainability we don't just have to think about solar panels or wind turbines. Among the indicators of sustainable development is the quality of education.

The 2030 agenda, as a sustainable development plan, seeks an action plan in favour of people, planet and prosperity.

Within these sustainable educational policies is the fight against early abandonment of education by fighting for the continuation of studies beyond the compulsory stage. This seeks positive effects on personal development and social progress, facilitating future access to the job market.

The "Broadening horizons" project is a study support program promoted by the Grupotec company, in which the IES El Cabanyal collaborates among other centres, which fights to ensure that young people at risk of social exclusion complete their basic vocational training studies. It provides a first approach of the company to the world of education, making young people see the importance of education as a tool that allows them to make positive changes in their lives.

Keywords: Agenda 2030; Sustainability; Early leaving of education.

How to cite: Soria Momparler, R. and Sornosa Cervera, D. (2024) Broadening horizons, sustainable development in education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 230-236. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

1.1. Program description

The "Broadening Horizons" project is a study support program carried out by the Grupotec company and aimed at young students at risk of social exclusion in the city of Valencia. The program has been implemented, among other colleges, at the IES EL Cabanyal in Valencia. It consists of a series of activities that seek to create a company-student interaction to convey to them the importance of education and sustainable development as a tool for change and control in their lives.

The IES El Cabanyal is a Vocational Training Center located in Valencia, Spain, and has about 1,500 students, 160 teachers, cleaning staff and administrative services staff. Of the total student body, around 900 are from Vocational Training Degrees from different professional families; Electricity and Electronics, Installation and Maintenance, Personal Image and Transportation and Vehicle Maintenance.

Grupotec is a company created in 1997 at the initiative of a group of engineers, which has evolved and grown to become a large multidisciplinary engineering and architecture company and a leader in the photovoltaic energy sector.

1.2. Beneficiary profile

The project is aimed at students between 15 and 17 years old who are taking their first course of Basic Vocational Training Degree in Electricity and Electronics. The program is designed for young people at risk of social exclusion, although all students that make up the group where it is applied may be part of the program. This is done because a symbiosis is also sought between the different social profiles of the students so that equality and social inclusion are promoted.

1.3. Aim

The project aims to achieve the following objectives:

- Reduction of school absenteeism.

- Increased motivation to study as a key to success.

- Promotion of reflection and vision of the future.

- Preparation for the future work market.

- Bring them closer to the world of renewable energies.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1.4. Methodology

Changing the mentality of the students is vital to the success of this project. Making them see that they have gone from compulsory secondary education, Middle School, to vocational training. The College becomes a place that simulates a work environment. The program's methodology is based on exposing students to new environments and situations to which they do not have access in their daily lives. Through introduction to the world of business, meetings with professionals and participation in practical workshops, students will have the opportunity to explore diverse perspectives and horizons. This exposure will enable them to understand the relevance of education in their daily and future life, and inspire them to strive for a better future. Sustainability must begin in the individual and in society as an action that favours personal social progress and thus benefits the planet.

2. The project

The "Broadening Horizons" program is a non-profit initiative promoted by Grupotec, the result of a deep social awareness of its Management. The goals of this project are solidly altruistic and oriented toward creating transformative opportunities for participants. The success of this project and its development depend crucially on the active and committed collaboration between all parties involved. Participation and commitment are essential to ensure that this free program can be carried out effectively and meets its objectives.

2.1. Communication

Communication between the college and the company is vital to ensure effective coordination between both parties. Both ends have personnel dedicated to this task. In the case of IES EL Cabanyal there is a teacher who has a direct relationship with the students and who will be present in all the group activities carried out as part of the program. His role will be to guarantee a solid connection between IES EL Cabanyal and Grupotec, facilitating the transmission of information, resolution of queries and constant collaboration for the benefit of the participants.

2.2. Evaluation and monitoring

The IES El Cabanyal assumes the responsibility of collaborating in the evaluation and monitoring of the sessions of the "Broadening Horizons" program with the aim of ensuring the effectiveness and constant improvement of the program.

Session Assessment

Assessint each session in terms of content and student attitude. Providing detailed and constructive feedback that allows a deep understanding of the students and effectiveness of the activities carried out.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The evaluation will identify areas of improvement and opportunities for adjustments in the implementation of the program, optimizing the dynamics of activities and company-student interaction.

Monthly records

These records will provide quantitative information on student attendance and participation in activities as an objective basis to determine scholarship recipients each month.

End of course meeting

At the end of the course, a meeting will be held between IES EL Cabanyal and Grupotec to carry out a global analysis of the project. Examine the results obtained, the challenges faced and the lessons learned throughout the school year. This review will provide a comprehensive understanding of the program's impact and guide future improvements and adjustments.

2.3. Involvement of the Grupotec company

As a promoting entity, Grupotec assumes an unwavering commitment to the success of the "Broadening Horizons" program, taking responsibility for all aspects related to the financing, design, implementation and coordination of all program activities, as well as the enrollment documents for the awarding of monthly scholarships.

Furthermore, given the nature of the program and the contact with minors, Grupotec undertakes the collection of the Certificates of Crimes of a Sexual Nature from all employees involved in the project and forwarding them to the college.

3. Scholarship program

3.1 General description

A scholarship program has been created in order to motivate students to actively participate in the project and encourage regular attendance, in order to reduce school absenteeism and improve attitude in class.

It has been sought to cover the period of the school year, from the month of October to June (both included) and will consist of a total of €40 per month, per participant, in the form of supermarket coupons, for the purchase of basic necessities items.

3.2 Allocation

It is important to ensure the purpose of the project, which is why rigorous and objective allocation criteria must be followed. This ensures that obtaining the scholarship is a valuable and meaningful incentive, and that those who meet the requirements are rewarded for their efforts.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

All students participating in the project will be eligible to obtain a monthly scholarship, however, their award will be carried out based on the following established requirements:

- **Class attendance**: The teaching team will be responsible for assessing the attendance of each participant in class every day and developing a selection criterion based on it.

- **Attitude**: The teaching team will be responsible for assessing the attitude of each participant in class and during the project sessions. In this way and according to an established criterion, they will be in charge of establishing which students have had an attitude worthy of a scholarship and which students have not at the end of the month.

- **Project assistance**: It will be an essential requirement that students attend 100% of the sessions included in the project. At the beginning of each session an attendance record will be recorded; one or more unjustified absences will imply the loss of that month's scholarship. Delays of more than 10 minutes will also be considered absences.

The award is independent of decisions made in previous months. This ensures that all students have the opportunity to be recognized for their effort and dedication in an equitable and consistent manner.

For the assessment of these scholarship award requirements, a monthly registration document has been prepared to be filled out by the teaching team and which must be sent to Grupotec no later than the first week of the following month.

3.3. Scholarship Awards

This task falls to the teaching staff responsible for the project at IES EL Cabanyal. In the case of students who do not receive the scholarship due to non-compliance with any of the 3 essential requirements, the reason will be justified in order to make them understand the importance of work and effort, just as in the real world.

4. Details of activities

The scheduled activities will be distributed throughout the entire academic period, spanning from September to June.

4.1. Program presentation

With the aim of encouraging participation in the program, two presentation sessions will be held, one aimed at students and the other at families, preferably coinciding with the session at the beginning of the school year.

4.2. Mentoring

This is the most valued activity in the first edition of the project and also the one that Grupotec considers to have the greatest impact on the participants. Therefore, it is essential

2024, Editorial Universitat Politècnica de València BY-NC-SA

that the teaching team collaborate by transmitting to the students the importance of carrying out this activity.

Pairs of two students will go to the company offices, where they will be received by a volunteer mentor who holds a job related to the type of studies they are carrying out. Each couple will have the opportunity to participate in three sessions throughout the course, lasting 1 hour each.

- Session 1: The first contact will be mainly so that the mentor and the student get to know each other. The mentor will present the company and their functions within it, explaining the path taken to get there. In addition, they will take the opportunity to make the students reflect on their training and employment prospects.

- Session 2: The tasks that make up the mentor's job will be explored in depth, choosing a simple one for the students to perform under supervision. An attempt will be made at all times to ensure that the task is related to the syllabus already seen in class.

- Session 3: Similar to the previous session, students will be involved in other tasks so that they can put into practice the knowledge acquired in class. It will conclude with a reflection on the results of the school year and the objectives for next year.

In addition to encouraging reflection and a vision of the future, these interactions seek to bring students closer to a work reality that they may see as very distant, putting them in a real situation and increasing their confidence in their abilities to achieve their objectives.

4.3. Company visits

Companies from different sectors that are interesting to the students will be visited, so that they can observe various forms of work and visualize some concepts addressed in the classroom.

4.4. CV and interview workshop

Providing Grupotec's perspective and business experience, this workshop aims to prepare students to face the job search process and improve their employability. The workshop will consist of two parts:

- Resume writing workshop: Grupotec's HR professionals will give a practical session at the College with tips for writing a resume, offering the valuable insight of the interviewer.

- Intensive interview preparation workshop: in collaboration with the "Quiero Trabajo" Foundation, an intensive 3.5-hour workshop will be held focused on the "first impression in interviews." The session will dynamically address various relevant topics, including understanding a job interview, emotional management during interviews, effective

BY-NC-SA 2024, Editorial Universitat Politècnica de València

preparation, identifying strengths and areas for improvement, among others. Details of the workshop content will be shared in the near future.

4.5. Simulation of selection process

The CV and interview workshop will culminate with a simulation of a real selection process, carried out by HR professionals from Grupotec. Students must appear at the office on the agreed date and time, following the same conditions as in a real job interview, with their resume and an appropriate attitude. Interviews will be individual and constructive feedback will be provided to all participants. The finally selected student will have the possibility of doing an internship at Grupotec or at one of the companies collaborating in the project, as long as they are of the necessary legal age and the corresponding agreement is made.

4.6. Final Project Work

To invite students to reflect on the project and practice basic work skills such as the preparation of simple documents, they will have to make an activity report throughout the course in which they summarize each of the project sessions, express their opinion and make a little reflection. At the end of the program, the documents will be collected and assessed by a committee of Grupotec volunteers, choosing the best work, whose author will receive a prize related to their degree.

4.7. Closing session

A final session will be held at the end of the course, in which the students' opinions on the project will be collected in order to make adjustments and improvements for future editions.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

All the work was developed using experience through years of work teaching basic VET.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Fighting Energy Poverty through multi-level energy education: the "Citizen School for the Right to Energy" in the City of Valencia (Spain)

N. García-Lepetit[a], C. Ferre[a], P. Jordá[b] , E. Rocher[a], B. Costa-Ruiz[c], S. Igual[a], A. Zea[b], C. Girard[b], J. Valls[b], V. Pellicer-Sifres[b] , P. Ambrosio-Albala[d]

[a] Fundación de la Comunidad Valenciana para la Promoción Estratégica, el Desarrollo y la Innovación Urbana (Las Naves), Spain

[b] Fundación Valencia Clima i Energia, Spain

[c] Kveloce I+D +I, Spain

[d] University of Leeds, United Kingdom

Abstract

To face-up the rising problem of Energy Poverty, alongside major structural interventions, delivering energy literacy to users provides useful skills and knowledge to decrease energy costs without losing comfort. The pilot urban program "Citizen School for the Right to Energy" (CSRE) implemented in the city of Valencia (Spain) from 2022 until mid-2024 aims at improving health and wellbeing of people in energy poverty through education-related initiatives and assess its impact with a sound research study. The interventions have been designed based on the social ecological model, to impact on the different layers influencing individuals' health status. Specifically, these are actions oriented to: promote individual behavioural change related to energy efficiency such as personalised energy advice and trainings (layer 1); strengthening social networks by building a peer learning community (layer 2); improve home comfort through home audits and the installation of efficiency kits (layer 3); raise public awareness and advocacy on the Right to Energy to impact on the general social and political conditions (layer 4).

This paper describes the CSRE program, case study of the social ecological model applied to the design of an educative urban program to fight Energy Poverty. The program and research study are currently on going, and preliminary conclusions give already insights into the impact and best practices on the different layers of the social ecological model.

Keywords: energy literacy; energy poverty; right to energy; urban programs; social ecological model

How to cite: García-Lepetit, N.; Ferre, C.; Jordá, P.; Rocher, E.; Costa-Ruiz, B.; Igual, S.; Zea, A.; Girard, C.; Valls, J.; Pellicer-Sifres, V and Ambrosio-Albala, P. (2024) Fighting Energy Poverty through multi-level energy education: the "Citizen School for the Right to Energy" in the City of Valencia (Spain). In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 237-245. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Energy Poverty (EP), understood as the situation in which households cannot afford essential energy services to live in dignity, is a widely spread problem, with 9,3% of European population (around 40 million) unable to keep their home adequately warm (Eurostat, 2022), leading to important impacts on their health (Thompson et al, 2017). The recent crisis due to COVID-19 pandemic, the war against Ukraine, and worldwide inflation since 2022 have resulted in a large-scale increase of the energy costs, exacerbating the problem. Furthermore, rising temperatures with climate change are adding the new dimension of summer EP in Southern areas of Europe (D. Torrego-Gómez et al, 2024). EP and potential mitigation measures have been widely proposed by researchers and policymakers in the last years, including specific policy recommendations recently issued for EU state members (EC, 2023). However, the EP indicators are not showing significant improvements and the European Commission itself recognises the need for further actions at national level (EC, 2023). Alongside individual financial situations, there are structural reasons behind EP, such as the low energy efficiency of buildings and appliances, and the characteristics of the complex and volatile energy market. These factors are even more difficult to address if we consider that technical or expert knowledge is required to fully understand concepts related to energy efficiency, energy market, energy bills, cost-efficiency of home interventions, access to subsidies, etc., necessary to optimize energy consumption and reduce costs.

In view of the above-mentioned challenges, many interventions against EP provide energy literacy, defined as an individual's energy-related knowledge, everyday practices, and the attitude towards energy efficiency (DeWaters and Powers, 2011). They usually include energy assessment, information points and trainings to users, providing them with useful knowledge and skills to reduce their energy consumption, lean to energy efficient choices, optimize their energy bills, apply low-budget solutions to their homes, access to government funds, renewables energy information, etc. There are also some programs where people are trained to become new energy advisors to obtain a multiplicator effect in the spreading of energy knowledge and create employment at the same time (e.g. EU projects ACHIEVE, ASSIST or HELP). A few initiatives also focus on giving energy education to non-energy-related professionals (such as social workers or health professionals), so they can help identify people at risk and provide them with the appropriate tools (e.g. Energy Ambassadors initiative, Warm Homes Prescription program, EU project STEP or the School of Energy of Naturgy Foundation). An extensive list of programs can be found in the Atlas of Energy Poverty initiatives in Europe (ECOSERVEIS, 2017).

However, informed action from individuals at their homes is not enough to eradicate the problem and major transformative political actions are required as well to tackle EP (N. Simcock, 2023) related to buildings renovations, heating systems, energy model, etc. For

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

this, EP awareness and sound information should be spread across society and the political level. At this respect, a growing number of social movements (Right to Energy Coalition, Fridays for Future, etc.) and authors (e.g. Jiglau G. et al, 2023, Pellicer-Sifres, V., 2018) emphasize the need of a change in the paradigm around energy vulnerability and that a right to energy could be a key element for it. Although the United Nations has established energy as "essential for health, security, comfort, and nutrition" (UN, 1991), the concept of energy as a basic right is not widely recognised yet.

In this scenario, the urban program "Citizen School for the Right to Energy" was designed by Las Naves and València Clima i Energia, both public foundations of Valencia City Council, and implemented through the Energy Office of the latter, to mitigate EP through a holistic urban program based on different education-related activities. Embedded in the WELLBASED EU-H2020 project, its design was conceptualised under the social ecological model (Dahlgren and Whitehead, 1991), described in section 3.

2. The context: H2020 project WELLBASED

The goals of the H2020 project WELLBASED (2021-2025) are to design, implement and evaluate comprehensive urban programmes to reduce energy poverty and its effects on the citizens' health and wellbeing, built on evidence-based approaches.

Six pilot cities (Edirne, in Turkey; Heerlen, in Netherlands; Jelgava, in Latvia; Leeds, in United Kingdom; Budapest, in Hungary; and Valencia, in Spain) and one observer city (Skopje, Macedonia) participate in WELLBASED project, with urban EP programmes adapted to each local context, and more than 1300 participants recruited in total. A research program is also implemented to assess the impact on health of the interventions carried out, in relation to a control group, which has not received interventions. It includes quantitative and qualitative studies on health and energy habits, direct health measures and IoT devices installed at participants' homes to measure temperature, humidity and CO_2 levels (Stevens et al., 2022).

In the City of Valencia (Spain), the pilot urban programme has created the so-called "Citizen School for the Right to Energy", hereinafter CSRE.

3. Methodology framework: the social ecological model

The methodological framework adopted by WELLBASED is the social ecological model proposed by Dahlgren and Whitehead (1991), which describes the social and ecological determinants of health, i.e. how elements of the social, economic, and physical environment interact with the biological factors and behaviours of individuals and shape health status. Thus, the model defines different layers of influence, and WELLBASED urban programmes designs interventions against EP that in turn impact on various social determinants of health within these layers (individual behaviour, community, household conditions, local policies…).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The urban programme developed in the city of Valencia through the CSRE, specifically addresses the different layers of the model as follows: layer (1) individual lifestyle factor, providing personalised advice and training on energy efficiency and bill optimisation, mainly actions oriented to promote individual behavioural change related to energy efficiency; layer (2) social and community networks, building a community of knowledge exchange and peer learning aimed at strengthening community support; layer (3) living and working factors, practices aimed at improving access to those "services" necessary for decent work and living conditions, such as the home audits; and layer (4) general social and political socio-economic, cultural and environmental conditions, practices aimed at coordinating initiatives and defining public policies to address EP (see Table 1).

Table 1 – Urban intervention program at the City of Valencia based on the social ecological model

Layers	Name	Interventions
Layer 1	Individual lifestyle factors	- Energy assessment and trainings on energy efficiency, Right to Energy and bills optimization - Training to professionals (health, social workers,...)
Layer 2	Social and community networks	- Group meetings to exchange knowledge and experiences
Layer 3	Living and working conditions	- Home audits and installation of an efficiency kit
Layer 4	General socio economic, cultural, environmental conditions	- Communication campaigns to build public awareness on the Right to Energy - Sharing research results and policy recommendations with policy makers - Hackaton with university community

Source: Own elaboration

4. The "Citizen School for the Right to Energy" (CSRE)

CSRE is the urban program of the City of Valencia, one of the six pilot cities of H2020 project WELLBASED. Started in September 2022 (until August 2024), it focuses on delivering energy literacy and awareness on the Right to Energy at different levels, which have been organised in this section by recipient: (1) energy vulnerable people, (2) professionals working in close contact with people at risk of EP, and (3) public society and policymakers.

4.1 Energy literacy to energy vulnerable people

a. Energy assessment for energy vulnerable people

The intervention group consists of 134 households (145 individuals), identified as being at risk of energy poverty (having uncomfortable temperatures at home, living in an old and inefficient building and/or having difficulties in paying their energy bills). Each participant,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

when joining the program, receives a tailored home energy audit performed by an energy technician from València Clima i Energia. An energy kit consisting of LED light bulbs, window straps, power strip and an electrical timer is installed during the visit, alongside explanations on how to use each item. Also, a plug-in energy meter is included in the kit and all the consumptions of the different home appliances are checked together with the participants, so they can see their impact and receive energy efficiency tips.

The second part of the intervention is oriented to understand the energy bills. An in-depth explanation is provided about the types of energy markets (the regulated[1] and the free one) and the different types of tariffs. Also, the terms included in the energy bills are detailed, as well as potential additional services and fees. If the participant is eligible for the social energy bonus[2], a guidance is provided on how to request it.

During the first home visit, the energy coaches also install a sensor to measure temperature, humidity, and air quality of the house for a year. During the 6-month follow-up visit, the measurements and personalised advice are presented to participants, related to: temperature (e.g. improve isolation, lower blinds, use of fans or radiators efficiently), humidity (e.g. ventilation, painting, de-humidifiers) and air quality (e.g. ventilation cycles). This helps them understand better the conditions of the dwelling and potential health risks.

b. Regular meetings and peer-to-peer exchange between participants

Monthly 2h-workshops are offered at the Energy Office to participants, consisting of interactive learning sessions where participants can share their own experiences, led by front-line WELLBASED project staff and expert facilitators from Aeioluz cooperative.

Fig. 1 – Interventions of the School for the Right to Energy (left: workshops on energy efficiency; right: energy assessment at a participant's home)



Source: Own elaboration

[1] The so-called "regulated market" or Voluntary Price for Small Consumers (PVPC), recently reviewed in the Royal Decree 446/2023 of 13 June, is a contracting modality in the Spanish electricity market that incorporates a dynamic price indexed to the wholesale electricity market. (Spanish electricity market: Implementation plan (europa.eu))

[2] Discount on the electricity bill, ranging from 25 to 40% depending on the degree of consumer's vulnerability (Bono Social de electricidad (miteco.gob.es)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

A craft workshop has been also conducted with participants by Fractal Cooperative, with the support of WELLBASED front-line couches, to allow them to build narratives based on their own personal lived experience on EP through photos and collages, subsequently shared in an exhibition on the Right to Energy at Las Naves Foundation (February 2024).

4.2 Energy poverty trainings to professionals dealing with people at risk of EP

Building capacity among multiplier agents and referral services is crucial for maximizing their effectiveness in tackling energy poverty. By equipping these agents with the necessary knowledge, skills, and resources, they can better serve as catalysts in reaching and supporting vulnerable populations. Thus, it is foreseen to provide during 2024 capacity building training to key stakeholders that work with population that is at risk or in situation of energy vulnerability: NGOs, schools, local community networks and healthcare professionals.

These capacity-building sessions will provide them with specific skills such as understanding EP (causes, health determinants, consequences) and tools to identify situations of energy vulnerability, as well as the resources available for support.

Regarding health professionals and community networks, the training will specifically focus on capacitating these multiplier agents (General Practitioners, nurses, primary care social workers, community networks leaders, etc.) on the impacts of EP on physical and mental health, including gender inequalities. It will share preliminary results of the evaluation studies on participants, as well other project experiences on social prescribing applied to EP or vulnerability situations in other countries; they will finally explore the potential of piloting social prescribing in the regional healthcare system.

4.3 General awareness and policy advocacy aimed at public society and policymakers

Within WELLBASED urban program of Valencia, several events and communication campaigns have been carried out to raise public awareness and call to action to policymakers on the problem of EP and its impact on health.

Regarding general awareness about EP problem, a communication campaign was launched locally in February 2023, spreading the concept of the "Right to Energy", through public city advertisement panels (stating: "We all have the Right to Energy") and social networks, informing about this rising problem and directing to Energy Office to get support. This, alongside other public events (presentations and round tables with different entities engaged in EP fight, workshops at the Energy Office, etc.), have been organised during the annual week of Energy Poverty, to join efforts with other national agents and abroad.

As far as policy advocacy is concerned, WELLBASED project includes the creation of policy recommendations, based on the project research results, and adapted to each local context, which will be spread at the end of the project (2025). Additionally, the communication

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

campaign "Manifesto for healthy homes" has been launched in March 2024, inviting EU local authorities to commit to include EP and its health impact in their political agendas.

Finally, a "hackathon" (i.e. an event where people come together to solve a specific challenge) will be organised in April 2024 involving the university community. After some training sessions about EP, students will be engaged in mitigating a problem specifically encountered in Valencia's urban program, namely, summer EP and its impact on health.

5. Conclusions

The "Citizen School for the Right to Energy" (CSRE) is a case study of the social ecological model applied to design an urban program to fight Energy Poverty. Through education-related initiatives targeted to the people affected and other key agents of the city, CSRE intends to improve the health and wellbeing of people in EP. Although the program has not finished yet, some conclusions and best practices can be raised already.

Regarding individual lifestyle (layer 1), the energy customized assistance has provided useful tools and tips to 145 people at risk of EP (recruitment number stated in the project proposal), for behavioural change towards more energy efficiency at home and lower energy bills. Some of the knowledge and skills most valued so far by participants have been the appliances' use optimisation, information about how to access the social tariff discount offered by the government or the identification of unwanted extra services or insurances included in their bills by default. As expressed by participants: "Now I know how to read my bill, before I didn't even know what the PVPC was. […] It gives you a sense a power"; "These trainings have opened new horizons to me […] They take you out of the darkness and disinformation".

Concerning social and community networks (layer 2), the monthly group meetings (with an average of 15 attendees per meeting, more or less the attendance expected) have allowed a close peer-to-peer learning and the creation of a little support community, aimed at release mental tensions. Some participants report: "You have fun, it makes you get a move on and you get to understand the things they explain to you, I love it. […] We all share equally and we all benefit from it, it's nice"; or "You disconnect a bit from everything, you are with people from all ages, and you get aware of everything, it's very good".

As for the living conditions (layer 3), home audits were performed to 134 households, including the installation of the efficiency kit, obtaining some improvements in their home comfort. For example, taking control of consumptions with the time programmer and the consumption meter, less cool/hot draughts or less consumption while better illumination thanks to the LED bulbs, as reported by the participants. Regarding IoT devices' measurements, indoor winter and summer temperatures in 2023 were mostly below the recommended threshold of 18ºC and 24ºC, respectively (De Leede et al, 2023).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Lastly, CSRE communication campaigns to raise EP awareness, involving policymakers and spreading the concept of the Right to Energy across society, intended to have some influence on layer 4 (general socio economic, cultural, environmental conditions), emphasizing this problem and trying to foster action among policymakers. The effects of these kind of actions are difficult to assess at short term but a special focus has been put on the following measures: to take some steps towards a local strategy against EP, to maintain some features of the CSRE beyond the project, to collect more local indicators to measure and follow-up EP through the Statistics Office of the city of Valencia, and to develop joint activities between energy and health sectors. Additionally, summer EP has clearly shown to have a high impact on people's wellbeing (i.e. some households reaching inside temperatures of 36 degrees). Some actions have been already undertaken by the Energy Office at this matter such as trainings on how to fight extreme heat at home, both for participants and technicians.

WELLBASED research study will deliver its final results at the end of the program (end of 2024-2025) and will give more light to the effect of these interventions on participants' physical and mental health. The final conclusions will allow us to better determine whether the impact of education-based initiatives based on the social ecological model have a real impact on health and wellbeing and if and how they can be replicated.

Acknowledgements

This work was funded by the European Commission, through the H2020 Project "WELLBASED - Improving health, wellbeing and equality by evidenced-based urban policies for tackling energy poverty" (GA number: 945097). The authors would like to thank all WELLBASED Project partners, AEIOLUZ and Fractals, and all the participants of CSRE.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Dahlgren G & Whitehead M. (1991) Policies and Strategies to Promote Social Equity in Health. Stockholm, Sweden: Institute for Futures Studies, 1991.

De Leede, S., Van Grieken, A., Stevens, M. (2023), D 4.2 WELLBASED Intermediate Analysis Report, Public deliverable of project H2020 WELLBASED, https://wellbased.eu/wp-content/uploads/2023/10/WELLBASED_D4.2_Intermediate-analysis-report.pdf

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in NY State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*, 39(3), 1699–1710. https://doi.org/10.1016/j.enpol.2010.12.049

ECOSERVEIS, Atlas of energy Poverty (2016) https://www.ecoserveis.net/en/atlas-of-energy-poverty-initiatives-in-europe-state-by-state-review/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

European Commission, Directorate-General for Energy, Member state reports on energy poverty 2019 (2020) Publications Office, https://doi.org/10.2833/81567

European Commission, Commission Recommendation 2023/2407 of 20 October 2023 on energy poverty (2023) (OJ L, 2023/2407, 23.10.2023, ELI: http://data.europa.eu/eli/reco/2023/2407/oj)

Eurostat (2022) Economic strain. Inability to keep home adequately warm - EU-SILC survey. Online data code: ilc_mdes01. https://doi.org/10.2908/ilc_mdes01

Jiglau G., Bouzarovski S., Dubois U., et al. (2023), Review. Looking back to look forward: Reflections from networked research on energy poverty, *iScience* 26, 106083, March 17, 2023. https://doi.org/10.1016/j.isci.2023.106083

Pellicer-Sifres V. (2018). Ampliando la comprensión de la pobreza energética desde el enfoque de capacidades: hacia una mirada construida desde las personas afectadas. *Iberoamerican Journal of Development Studies* 7(2):138-163. https://doi.org/10.26754/ojs_ried/ijds.295

Simcock N. & Bouzarovski S. (2023) A cure-all for energy poverty? Thinking critically about energy advice. . Critical Social Policy, 0(0). https://doi.org/10.1177/02610183231219185

Stevens, M., Raat, H., Ferrando, M. et al. (2022) A comprehensive urban programme to reduce energy poverty and its effects on health and wellbeing of citizens in six European countries: study protocol of a controlled trial. *BMC Public Health* 22, 1578 (2022). https://doi.org/10.1186/s12889-022-13968-2

Thomson H., Snell C., Bouzarovski S. (2017) Health, Well-Being and Energy Poverty in Europe: A Comparative Study of 32 European Countries. *Int J Environ Res Public Health*. 2017;14(6).

Torrego-Gómez D, Gayoso-Heredia M., San-Nicolás Vargas P., et al. (17 Jan 2024): Recognising summer energy poverty. Evidence from Southern Europe, *Local Environment*, https://doi.org/10.1080/13549839.2024.2303456

United Nations, Committee on economic, social and cultural rights. General comment 4, the right to adequate housing (sixth session, 1991), U.N. Doc. E/1992/23, annex III at 114 (1991), U.N. Doc.in: HRI/GEN/1/Rev.6 at 18. 2003

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Valorisation of the Renewable Energy Capacity Building in Kenya

Francis Xavier Ochieng[1], Joseph Ngugi Kamau[1], Ephantus Kamweru[2]

[1] Institute of Energy and Environmental Technology, JKUAT,

[2] Institute of Energy and Environmental Technology, JKUAT

[3] The Rural Electrification and Renewable Energy Corporation

Abstract

In Kenya out of the 5,039 courses offered only 20 (0.04%) deal with renewable energy. Contrasted to Engineering (4.5%) or Technology (6.4%) courses, this is wholly inadequate if a critical mass of renewable energy experts is to be established. The mode of teaching these courses is mainly teacher-centred, where the students take the lecture and leave the class, to be assessed regularly by way of examinations. Which in essence is testing their rote memory. Coupled with such low numbers of training opportunities, is the lack of critical experts in renewable energy system value chains; with many of such experts being brought in from abroad when systems are being installed. The purpose of this work was to assess current practices in teaching renewable energy within the framework of the local capacity in manufacturing, installation, operation and maintenance of Renewable energy technologies and how value can be reinjected into it through scientific insights of the study.

Subsequently using methodologies such as the use of desk and field studies as well as employing mixed research methods, this study provides new findings demonstrating that valorization of Renewable energy education increases the critical mass of renewable energy experts, enhances the quality of training and research and most importantly attracts more institutions to offer renewable energy courses. The study assesses the value that the UK-AID-funded Transforming Energy Access Learning Partnership (TEA LP) has had on the M.Sc. Energy Technology program at JKUAT, both in curriculum development, curriculum contextualization and most importantly increased number of student applicants.

Keywords: Valorisation; Energy; Competency-based learning /Education; Capacity building; Kenya.

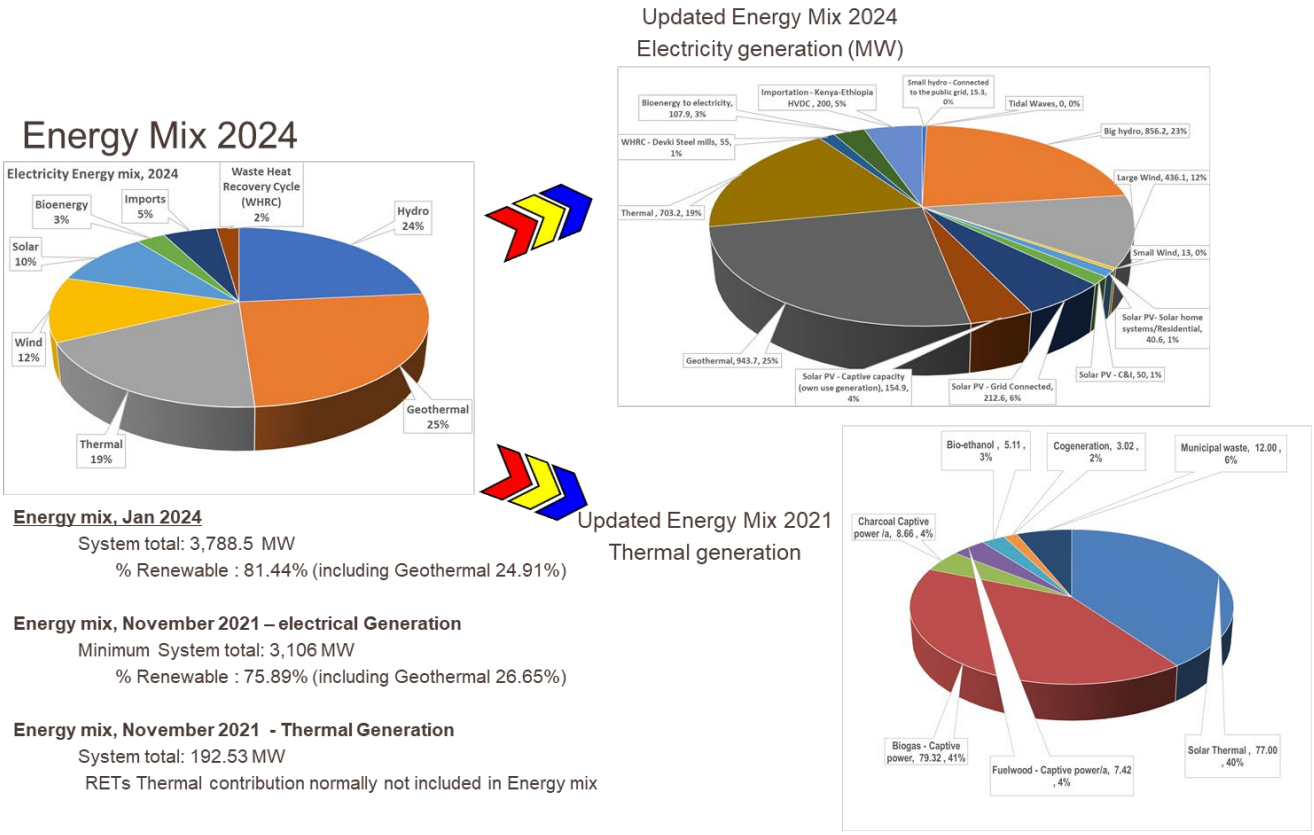
How to cite: Ochieng, F.X.; Kamau, J.N. and Kamweru, E. (2024) Valorisation of the Renewable Energy Capacity Building in Kenya. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 246-260. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1 Introduction

Kenya's energy mix consists of 81.44% (3,085 MW) installed from renewable energy resources and the remaining from Thermal-based fossil fuels. The thermal-based fuels comprise 703.2 MW and consist of 3 thermal (medium Speed diesel systems) totalling 614.52 MW and a 60 MW Thermal Gas Turbine. Under the Rural electrification program mandated within REREC, solar consists mainly of grid-connected (212.6 MW) and off-grid with an installed capacity of 90.6 MW. In addition, there are 27 mini-grids at 7.7MW and 4,500 grid primary schools at 1.3MW. The wind is mainly grid-connected from LTWP (300 MW) and off-grid wind (0.6MW). Concerning thermal (254 MW), Geothermal (678 MW), and Hydro (818 MW) the total installed capacity of 1.75 GW. Figure 1 details Kenya's energy mix, with non-fossilized thermal generation being included as part of the energy mix as part of the need to rethink and refocus on both electrical and non-electrical energy sources in the energy mix.

Figure 1: Contrarian Energy mix for Kenya



Source: Own elaboration

Apart from the focus in the published literature on electrical-based energy mix, another of the commonly utilized energy mix is its deficiency in describing the RE technology performance in the market space and along individual value chains. It only provides

BY-NC-SA 2024, Editorial Universitat Politècnica de València

information on the system that has been installed or decommissioned. In-depth information on the quality of the system is lacking.

One such way of understanding the quality of Renewable Energy installations is by analysis of the capacity and cadre (training qualifications and work titles) along the value chain for the people who manufacture, install, maintain and operate it. This ideally means looking at human capacity skills requirements for various RE-installed systems from the perspective of value chains.

The determination of a direct causal link between skills gaps and capacity training interventions in relation to global education training outcomes in application areas of management, information systems and social policy has been noted to be irregular or inconsistent [1]. To address this demerit, **realist literature reviews (RLS)** were historically proposed for this [2]. Realist reviews focus on either or both qualitative and quantitative evidence. At its core, the RLS first identifies the likely underlying working theory/approaches and then builds on it by analysing available literature evidence to verify whether and where these approaches are applicable [3]. Use of case studies in the latter regard has been found quite useful in testing and modification of the initial approaches [4, 5].

Unfortunately, such studies assessing the capacity of the human resources in terms of existing in operation as well as those in training have not been easily availed. This work thus seeks to address this research gap by undertaking an in-depth comprehensive study of human capacity in training as contextualized with the existing human capacity needs of the various renewable energy systems.

Subsequently, the following sub-sections analyse in-depth the methods and tools used as well the human capacity gaps and training approaches in the renewable energy sector.

2 Methods and tools

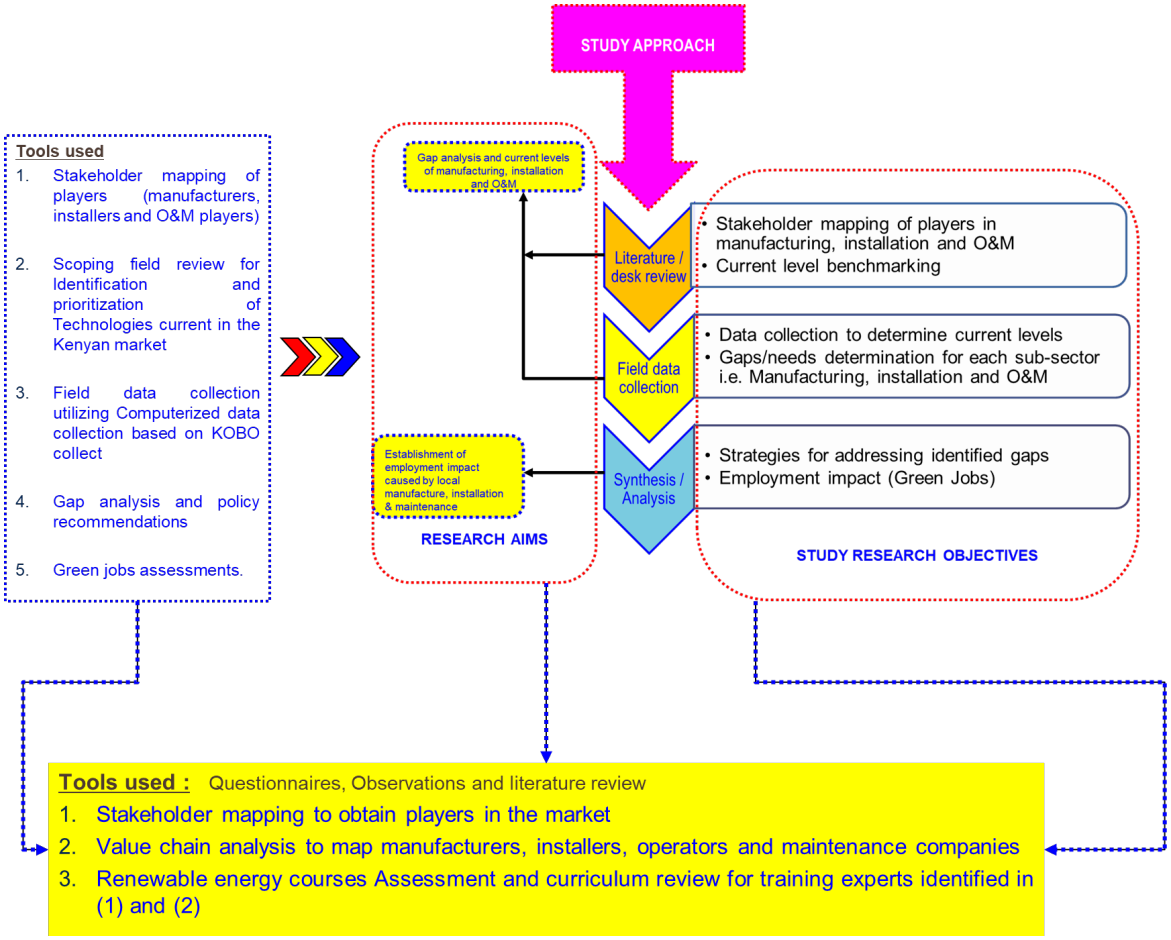
2.1 Methodology

Data and information presented in this study were collected through a mixed methods Research approach delineated in a three-step approach of (a) Meta-analysis to undertake a literature review, (b) field data acquisition, and (c) a synthesis and analysis stage that involved analysis of the capacity levels of the renewable energy value chains (with respect to manufacturing, installation, operation and maintenance) as well as the training opportunities to develop a critical mass of experts to fill positions within the energy value chains.

Detailed graphical descriptions of the tools and methods used for both baseline studies are shown in Figure 2

2024, Editorial Universitat Politècnica de València BY-NC-SA

Figure 2: Tools and methods used in Capacity development for energy chain volarization.



Source: Own elaboration

3 Results and Discussion

3.1 Capacity assessment for Tidal and ocean energy

3.1.1 Competency required

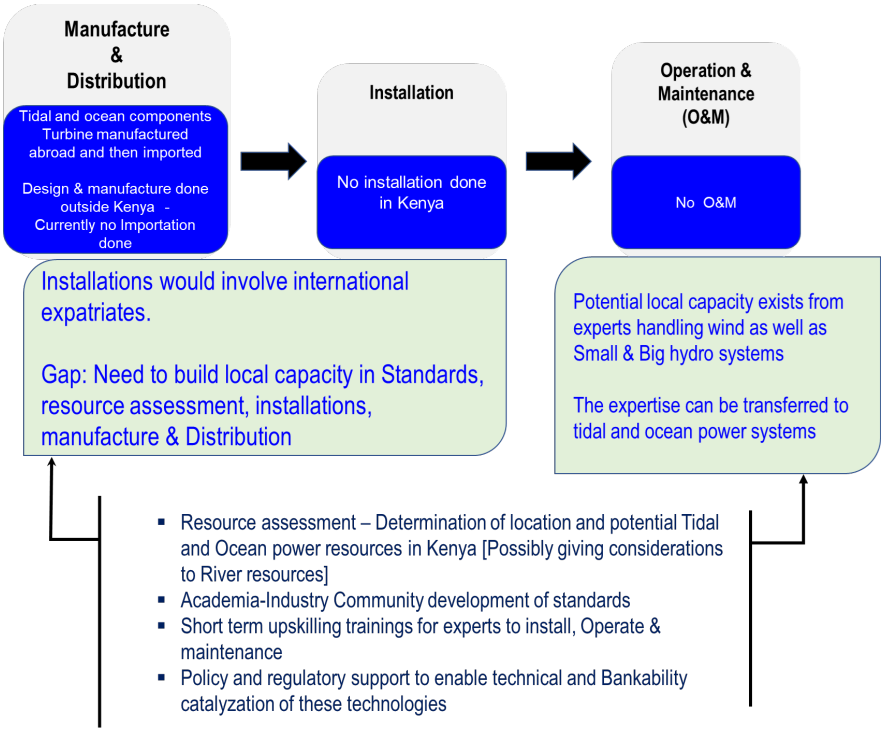
Unfortunately, there are no Manufacturers, installers, maintainers and operators of Tidal and Ocean power systems who are practising in Kenya. While several certified electrical and civil engineers exist, who may contribute significantly in this area. The lack of a standards environment coupled with near non-existence or practising capacity have probably made Tidal and Ocean not advance that much in Kenya.

3.1.2 Level of capacity (Capacity value chain)

This situation is encapsulated in Figure 7, which reveals a technical and commercial readiness level approaching zero (0),

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 3: Tidal and ocean power Capacity value chain



Source: Own elaboration

3.2 Capacity Assessment for Hydropower

3.2.1 Competency required

Generally, employment for big hydro, and to a limited extent for small hydro, is project-oriented. A high number of staff are employed in construction, manufacturing, installation and project development. Once the project is operational, skills and labour levels decrease significantly. A modest level of demand for operational and maintenance will exist.

3.2.2 Level of capacity (Capacity value chain)

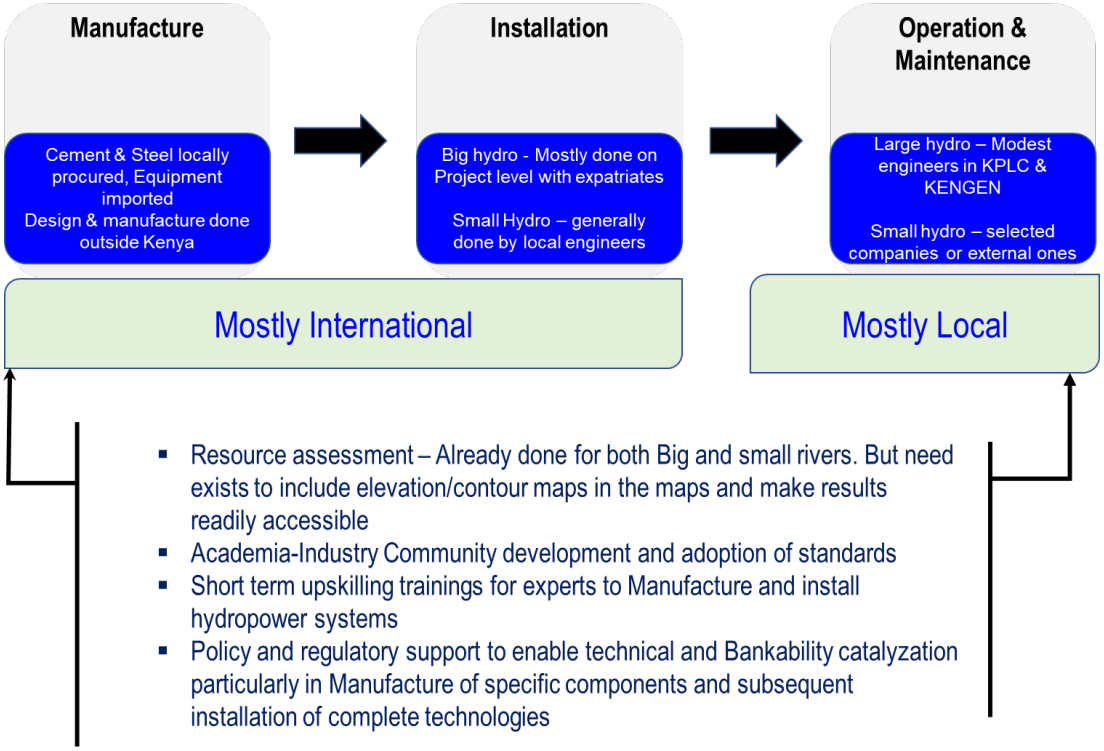
Generally, the country does not have experienced engineers and companies manufacturing and selling water turbines and related electromechanical water-driven generating equipment. A manufacturing deficit also exists for control systems. This is further complicated by the fact that most of the turbo-machinery tends to be custom-built for large hydropower stations. The high-level skills required for manufacturing include Hydropower systems design engineers and manufacturing engineers, who are unfortunately lacking in the country.

In the area of construction and installation requiring substantial civil works, civil engineers, construction workers and labourers are required. This stage normally requires the largest number of workers along the capacity value chain (Figure 9). However, due to the complexity and emphasis on manual labour, this stage will have lowly skilled construction labourers, with the majority of engineers coming from abroad. For the operation and maintenance, the main

2024, Editorial Universitat Politècnica de València BY-NC-SA

skills required are a technician and skilled craft level skills in operating and maintaining the equipment.

Figure 4: Hydropower Capacity Value Chain



Source: Own elaboration

3.3 Capacity assessment for Wind energy

3.3.1 Competency required

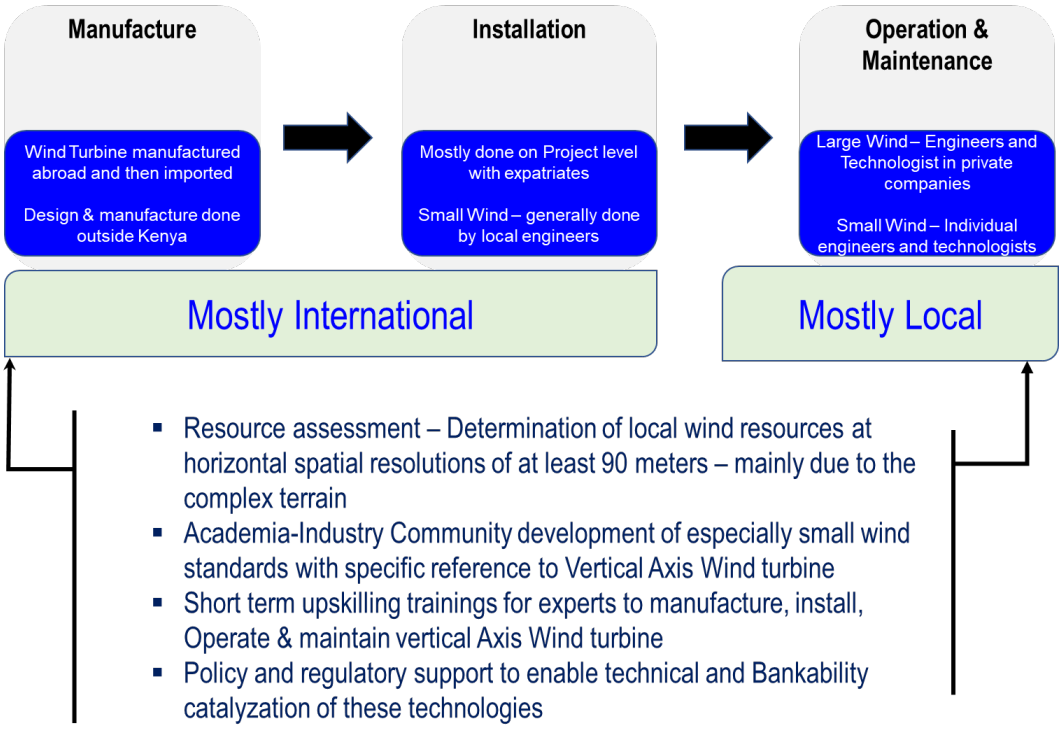
The employment capacity in the wind energy sector has various skills required across the various cadres of manufacturing, construction, installation, and O&M. The study notes that there are no manufacturing and installing capacities for electrical wind turbines. Capacities have existed for the manufacturing of mechanical wind pumps. Efforts have also been noted by one Kenyan Company that produces small wind turbines, but the sales have been reduced significantly due to performance issues.

3.3.2 Level of capacity (Capacity Value chain)

From the various cadres, the Wind capacity employment level value chain is developed (Figure 10). The skills required in the wind energy sector are similar to those normally available in the Manufacturing of any heavy mechanical and electromechanical product.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 5: Wind energy Capacity value chain



Source: Own elaboration

3.4 Capacity assessment of Solar PV and Solar Thermal

3.4.1 Competency required

Manufacturing the solar PV modules requires capital-intensive factories and the skills required are similar to those needed in developing and manufacturing electronic components in addition to manufacturing skills related to diffusing and processing silicon. For mounting of the panels to competencies required including fabrication, assembling and testing of the products. In the case of solar thermal, relatively simpler competencies are needed. For manufacturing, this requires metal or plastic fabrication skills, with some level of electromechanical skills for dealing with pumps and electronic control equipment. The latter can be sourced from other sectors.

Concerning the installation and construction of solar thermal systems, the competencies required are normally plumbing-related as well as heating-related. For small PV systems, a specialist photovoltaic installer or an electrician can do it. Where installation is to be grid-connected, advanced competencies in grid integration will be necessary

Lastly, for small-scale installations, maintenance and operation is pretty straightforward. For large-scale installations, competencies in maintenance will be consummate with the level of the technology. Most of the maintenance work in Solar technologies requires skills similar to

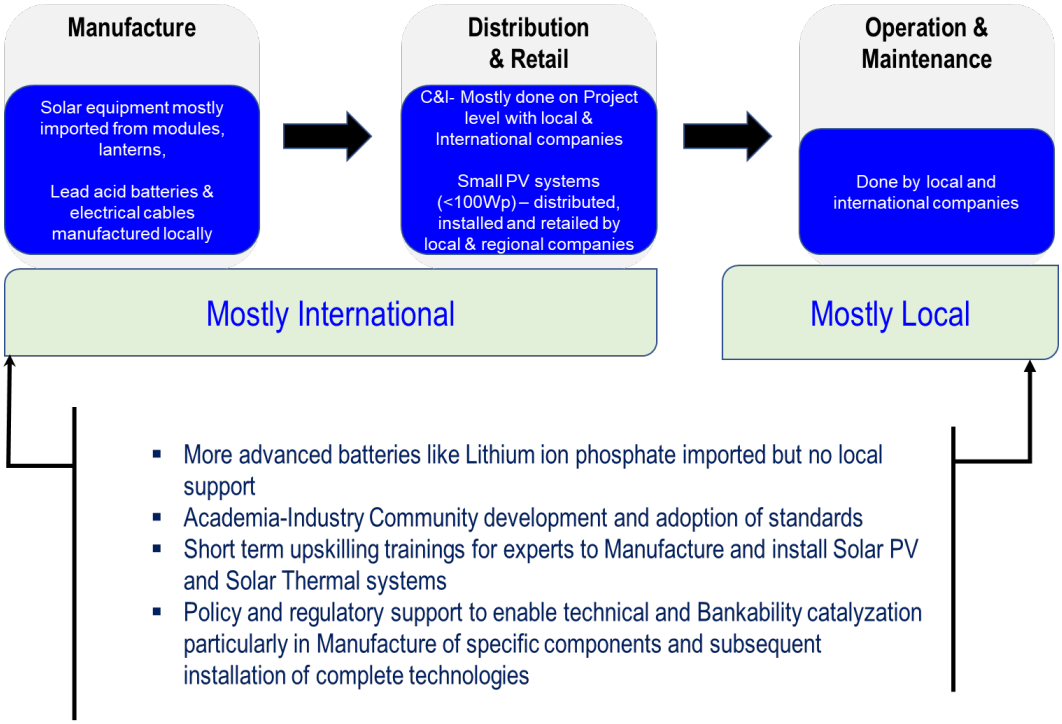
2024, Editorial Universitat Politècnica de València BY-NC-SA

those involved in installation. Generally, the main competencies required are those provided by technicians and skilled craft levels.

3.4.2 Level of capacity (Capacity Value chain)

Apart from batteries and cables, most of the equipment and components are manufactured abroad. Previously, some companies were making flat plate solar thermal collectors, but not so much anymore. Additionally, a company in Naivasha used to assemble Solar PV modules. But they are currently only doing distributions and installations (Figure 12)

Figure 6: Solar PV & Solar Thermal employment value chain



Source: Own elaboration

3.5 Capacity assessment for Bio-energy

3.5.1 Competency required

While several standards exist for the bioenergy sector, a huge gap exists in the standards that need to be adapted or adopted. This is linked to the efforts made in developing the technology as well as in human capacity development. The main efforts are competency development for the conversion science and the manufacturing of the equipment

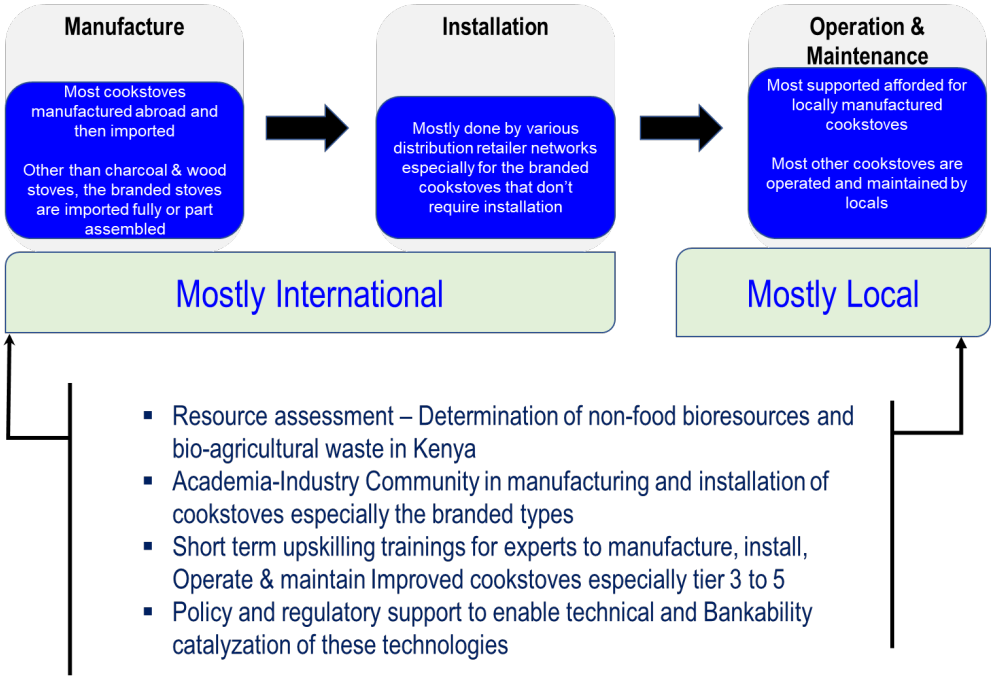
3.5.2 Level of capacity

By and large, the employment value chain is very limited to mainly installation and largely to operation and maintenance. For locally produced cook stove brands, manufacturing is also

BY-NC-SA 2024, Editorial Universitat Politècnica de València

done locally, however, majority of the branded cookstoves are either imported fully or partly complete (for assembling here) in Kenya.

Figure 7: Bioenergy employment value chain



Source: Own elaboration

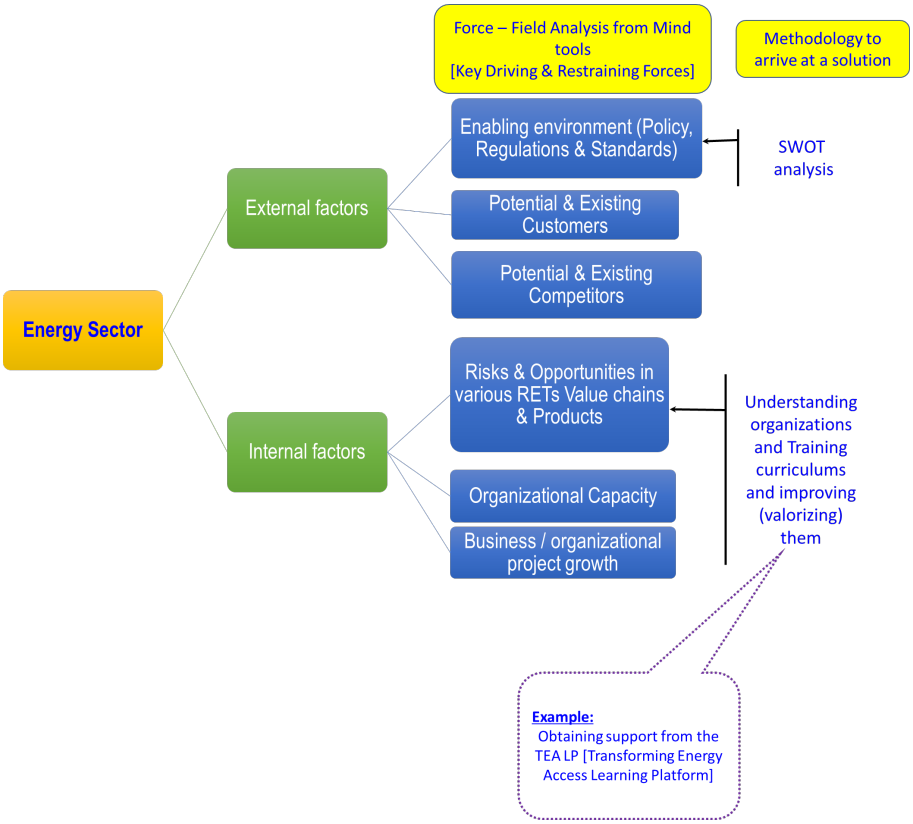
3.6 Training capacity

3.6.1 Situational Analysis for Training and Research Capacity

The need to emphasize training and research is based on the foregoing competencies gaps arising along various value chains. To add value (viz Valorization) to these value chains, one key component is to identify the training opportunities and improve them. Thus situational analysis of the training situation in Kenya not only benchmarks the current status of the energy sector but more so, gives insights and understanding of the environment in which energy planning can occur, and interventional areas excised. If so given within the context of a pre-planned project, it also provides an appreciation of the risks and benefits of the project as well as the organizations involved (Figure 8).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Figure 8: Force-field analysis for energy sector capacity development



Source: Own elaboration

3.6.2 Training Facilities and Teaching methodologies

Despite Kenya having 68 Universities and 2,300 Technical and Vocational Training institutions, only 15 Universities and less than 10 TVETS offer courses dedicated to Energy. Of the 33 courses offered at the University level, 3 are Doctorate level courses, 13 are undergraduate, 10 are Masters level and the rest are at certificate and diploma level [6].

Thus, despite the huge training gap very few institutions are offering training opportunities. In those institutions offering training, out of the 5,039 courses offered only 20 (0.04%) deal with renewable energy. Contrasted to Engineering (4.5%) or Technology (6.4%) of all courses, this is wholly inadequate if a critical mass of renewable energy experts is to be established. Further still when compared to the current 33 energy-based courses, there are 181 Engineering courses and 286 technology courses, thus demonstrating the wholly inadequacy of energy courses availability in building up a critical mass of energy experts.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1: Energy-based courses offered across Kenyan Universities

	University / TVET	Diploma / Certificate	Bachelor / Undergraduate	Masters	PhD
1	African Virtual University	Certificate in Renewable Energy			
	African Virtual University	Diploma in Renewable Energy			
	African Virtual University	Diploma in Renewable Energy - Heat production			
2	Dedan Kimathi University of Technology	PgDip in Geothermal Energy Technology			
	Dedan Kimathi University of Technology	Cert in Energy and Environmental Management	B.Sc in Renewable Energy Technology & management		
3	Jaramogi Oginga Odinga University of Science and Technology [JOOUST]		B.Sc In Renewable Energy and Environmental Physics		
4	Jomo Kenyatta University of Agriculture and Technology (JKUAT)			M.Sc in Energy Technology	PhD in Energy Technology
	Jomo Kenyatta University of Agriculture and Technology (JKUAT)			M.Sc in Renewable Energy	
	Jomo Kenyatta University of Agriculture and Technology (JKUAT)		B.Sc in Energy Engineering	M.Sc Sustainable Energy Engineering	PhD in Sustainable Energy Engineering
5	Kenyatta University		B.Tech in Energy	M.Sc in Sustainable Energy Engineering	
	Kenyatta University		B.Sc. In Renewable Energy and Biofuels Technology		
6	Kibabii University		B.Sc in Renewable Energy		
7	Kisii University		Bachelor of Science (Renewable Energy and Biofuels Technology)	M.Sc Renewable Energy Physics	
8	Masinde Muliro University of Science and Technology (MMUST)		B.Sc in Renewable Energy Technology		
	Masinde Muliro University of Science and Technology (MMUST)				

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

	University / TVET	Diploma / Certificate	Bachelor / Undergraduate	Masters	PhD
9	Moi University			M.Sc in Energy Studies	PhD in Energy Studies
	Moi University		B.Sc in Energy and Environmental Technology	M.Sc in Sustainable Energy Access	
10	Mount Kenya University		B.Sc in Renewable Energy and Technology	M.Sc in Renewable Energy and Environmental Engineering	
11	Multimedia University of Kenya (MMU)		B.Tech in Renewable Energy & Environmental Physics		
12	Technical University of Mombasa (TUM)		B.Sc in Renewable Energy Technology & management	M.Tech in Sustainable Energy Engineering	
13	Turkana University College		B.Sc in Sustainable Energy and Climate change systems		
14	University of Eldoret (UE)	Certificate in Renewable Energy			
15	University of Nairobi	Certificate in Renewable Energy		M.Sc in Energy Management	
	Count of courses	7	13	10	3

[6]

The main training approach is mainly traditional where the teacher forms the centre of learning [7]. The courses are mainly explicitly taught through lectures and teacher-centred demonstrations, with a few of the courses having students undertaking laboratory-based experiments and competency acquisition assignments. Generally, the teaching method across all the renewable energy courses has been determined to be direct instruction (teacher-centred) approach, with some universities employing in some particular courses inquiry-based learning, that integrates student investigation and hands-on learning. These two approaches have been noted to be wholly inadequate especially if the aim is to create innovative competencies, for students to fill the gaps in the energy value chains previously identified [7].

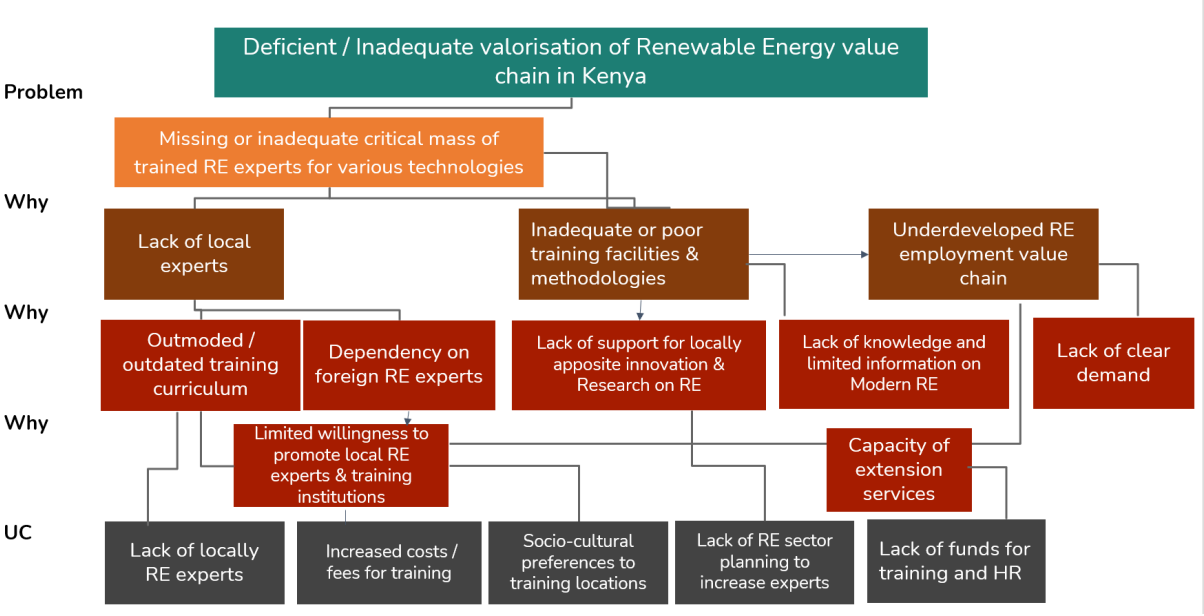
3.6.3 The paradigm shift through Training networks and partnerships

Aside from teaching methods, all the renewable courses were instituted long before 2019 and generally have not been revised to take into consideration the changes that have taken place in terms of off-grid devices, grid and hybrid systems as well as demand and supply innovations in the last half-decade. A need thus exists for revision of the programs and inculcation of new teaching and learning areas. This however is not trivial, since it requires financing and support, which can be obtained by cultivating partnerships and engaging in

BY-NC-SA 2024, Editorial Universitat Politècnica de València

training networks. A problem tree analysis (Figure 8) was thus undertaken to understand the root causes that link training to the job gaps in the Renewable energy marketplace.

Figure 9: Problem tree analysis for Lack of skilled experts within the various Renewable Energy value chains



Source: Own elaboration

Figure 8 demonstrates a challenge in the value addition of Renewable energy value chains due to an insufficient critical mass of trained experts. This arises from various underlying causes (UC) that can be attributed to training and training facilities. A paradigm shift thus exists to turn these institutions and their training approaches through networking and support.

A case for this is noted by Jomo Kenyatta University of Agriculture and Technology, which has sought to revitalise its courses with significant benefits. For instance, before the year 2022, the Institute of Energy and Environmental Technology (IEET), of Jomo Kenyatta University of Agriculture and Technology (JKUAT) was receiving between 5 to 7 students for its M.Sc (Energy Technology), but leveraging on the provision of scholarships from the German Academic exchange services (DAAD) and joining the Transforming Energy Access Learning Platform (TEA LP) network which enabled it to analyse and adapt its curriculum to modern energy needs as well as change it teaching methodologies to Blended (Competency Based) Learning, where the focus of learning is the student, turned the dismal outlook. For its September 2023, IEET recorded a total of 160 applications for the energy program. For September 2024, it has recorded so far 170 applications for the same.

Thus a paradigm shift to learning methodologies and teaching approaches based on value chain understanding of the energy sector can be developed.

2024, Editorial Universitat Politècnica de València BY-NC-SA

4 Conclusion

Arising from these aspects, it becomes clear that that mix of learning partnerships and revising the curriculum to meet the needs of the energy sector must be necessary catalysts for enhancing the vision of a critical mass of trained energy experts. In understanding the needs of the energy sectors, a schematic capacity-based value chain for each energy type becomes key. It is only as these are done among other catalytic efforts that the value (valorisation) can be brought into the capacity building in Renewable Energy.

Acknowledgements

The authors would to thank the CEO and the management of Rural Electrification and Renewable Energy Corporation (REREC) for sponsoring this study through tender RFX No. 1000000654

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Stewart, F., Technology and underdevelopment. Development Policy Review, 1977. 10(1): p. 92-105.

Curtain, R., Youth and employment: A public policy perspective. Development Bulletin, 2001. 55(1): p. 7-11.

Chambers, R. and G. Conway, Sustainable rural livelihoods: practical concepts for the 21st century. 1992: Institute of Development Studies (UK).

Lucas, H., et al., Renewable Energy Jobs: Status, Prospects & Policies. Biofuels and grid-connected electricity generation, 2011.

Paré, G. and S. Kitsiou, Methods for literature reviews, in Handbook of eHealth Evaluation: An Evidence-based Approach [Internet]. 2017, University of Victoria.

Pawson, R., et al., Realist review-a new method of systematic review designed for complex policy interventions. Journal of health services research & policy, 2005. 10(1_suppl): p. 21-34.

Shepperd, S., et al., Can we systematically review studies that evaluate complex interventions? PLoS Medicine, 2009. 6(8): p. e1000086.

Otte-Trojel, T., et al., How outcomes are achieved through patient portals: a realist review. Journal of the American Medical Informatics Association, 2014. 21(4): p. 751-757.

Rousseau, D.M., J. Manning, and D. Denyer, 11 Evidence in management and organizational science: assembling the field's full weight of scientific knowledge through syntheses. Academy of Management Annals, 2008. 2(1): p. 475-515.

Education, C.o.U., Approved Academic Programmes offered in chartered Universities in Kenya. 2023, Commission of Univesity Education: Nairobi. p. 89; Available from:

BY-NC-SA 2024, Editorial Universitat Politècnica de València

https://www.cue.or.ke/images/Approved_Academic_Programmes_Offered_Universities_in_Kenya_December_2023.pdf.

Kaume-Mwinzi, R.K., Teaching Practices in the 21st Century in Kenya: A Qualitative Approach. International Journal of Educational Excellence, 2018. 4(1): p. 77-99; Available from: https://pdfs.semanticscholar.org/256a/41ef052d0c8d534661b8740947b1fa04105f.pdf.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Environmental and Energy Management Systems (EEnMS) in Salesian Educational Institutions in Ecuador

Xavier Serrano-Guerrero[a], John Calle-Siguencia[a] , Pablo Arévalo-Moscoso[b], Fernando Pesantez-Avilés[c], Juan Cárdenas-Tapia[d]

[a] Energy Transition Research Group, Universidad Politécnica Salesiana, Ecuador

[b] Grupo de investigación y evaluación dela biodiversidad (GIVABI), Universidad Politécnica Salesiana, Ecuador

[c] Cátedra Unesco tecnologías de apoyo para la inclusión educativa, Universidad Politécnica Salesiana, Ecuador

[d] Grupo de Investigación Aprender a Aprender (GIAA), Universidad Politécnica Salesiana, Ecuador

Abstract

The growth of the human population in recent decades has led to a significant increase in resource demand, resulting in unsustainable exploitation. The Salesian Inspectorate of Ecuador, which coordinates and supervises the activities of the "Salesian missions" in the country, is fully aware of the historical moment of humanity. This paper provides the methodology that has served as a guide for incorporating Environmental and Energy Management Systems in Salesian Educational Institutions in Ecuador. This process involves the creation of a national committee, training, internal diagnosis, improvement proposals, and action plans. The main goal is to prevent and mitigate environmental impacts, thus promoting sustainability within the institutions. In this regard, each institution, with the support of the national committee, determines its weaknesses and priorities, internalizing and consciously incorporating them into its action plan, thereby promoting environmental care. In general, proposed improvements by each EI include, the reformulation of subjects related to energy, environment and sustainability, changes in technology for energy and water savings, monitoring of air pollution, and innovative ideas for waste separation, recycling, reuse, and green area care. In particular, it has generated enthusiasm within each educational unit, evidencing both positive and negative environmental practices. People, including students, have committed themselves to the Environmental Program.

Keywords: Environmental and Energy Management System; Educational Institutions; Sustainable and Energy Education.

How to cite: Serrano-Guerrero,X.; Calle-Siguencia,J.; Arévalo-Moscoso, P.; Pesantez-Avilés, F. and Cárdenas-Tapia,J. (2024) Environmental and Energy Management Systems (EEnMS) in Salesian Educational Institutions in Ecuador. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 261-269.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Human population growth in recent decades has led to a significant increase in demand for resources, resulting in unsustainable exploitation. With the population expected to exceed 10 billion people by 2100 (Hannah, 2019), the pressure on the biosphere will rise dramatically, increasing the imminent risk of mass extinction. For example, the average relative population abundance of animal species plummeted by 69% between 1970 and 2018 (Almond et al., 2020). Moreover, there are alarming decline rates that could lead to the extinction of 40% of the world's insect species in the coming decades (Sánchez-Bayo & Wyckhuys, 2019). Human activities manifest in water pollution, soil degradation, and climate change. Only a quarter of the planet's surface soil is estimated to be free from human activities (IPBES, 2019). Moreover, current atmospheric CO_2 concentrations is around 420 ppm, surpassing the desired maximum of 350 ppm breached in the 1980s (Tans et al., 2024). To limit the global temperature rise to within 2°C above pre-industrial levels, our efforts must triple, and to limit the increase to 1.5°C we should multiply the efforts by five (P. R. Shukla et al., 2019).

The Salesians are a religious order present in 132 countries, whose primary mission is to educate and serve young people, especially those in vulnerable situations. The Salesian Inspectorate of Ecuador, which coordinates and supervises the activities of the "Salesian missions" in the country, is fully aware of the historical moment of humanity. It has assumed the task of incorporating a process of reflection on the environmental impacts of its activities in all Salesian organizations. This includes the integration of renewable energies, the implementation of best practices, etc (*Don Bosco Green Allience*, 2024). The objective is to promote, through example, a healthy environment, responsible for the planet's biodiversity, and to educate a new generation committed to sustainable development (*Salesianos Don Bosco*, 2024).

This paper provides the methodology that has served as a guide for incorporating Environmental and Energy Management Systems (EEnMS) in Salesian Educational Institutions in Ecuador. This process involves the creation of a national committee, training, internal diagnosis, improvement proposals, and action plans. The main goal is to prevent and mitigate environmental impacts, promoting sustainability within the institutions. In this regard, each institution, with the support of the national committee, determines its weaknesses and priorities, internalizing and consciously incorporating them into its action plan, thereby promoting environmental care.

2. Related works

In recent years some authors ave worked on the Environmental Management Systems (EMS). In (Gomes et al., 2023), the authors carried out the maintenance of an EMS in a private

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Brazilian higher education institution to address sustainability and environmental performance. The Education Institutions (EIs) have challenges and limitations in the implementation of EMS, escencially organizational factors (O'Keeffe et al., 2020). The first organizational factor required is the determination to institutionalize the concept of sustainability for distributing knowledge and skills for sustainable development. In other work (Roos et al., 2020), the authors focus on the concept of environmental management performance in higher EIs. The use of key performance indicators (e.g., outdoor air quality, ecological footprint, energy consumption, GHG emissions), can help assess and improve the environmental impact of EIs, considering their unique structures and requirements (Lo-Iacono-Ferreira et al., 2018). Nevertheless, there are currently no common practices to address environmental management in EIs (Roos & Guenther, 2020).

On the other hand, the incorporation of Energy Management Systems (EnMS) in EIs is fundamental to educate and to raise awareness, for improving sustainability and reducing environmental impacts. The integration of different distributed generation technologies (Serrano-Guerrero & Escrivá-Escrivá, 2015), solar water heating systems (Pesantez-Pesantez et al., 2017), and digital control systems to manage loads (Serrano et al., 2016) are becoming more and more common in buildings, however, the EIs face several barriers to implementing EnMS compared to the private sector. EIs tend to adopt structured EnMS through less formal methods or modified approaches based on institutional drivers for implementation (Maneesha et al., 2020). Furthermore, the implementation of Energy Information and Management Systems in academic institutes is limited due to lack of awareness and relevant green policies (Zeeshan & Jamil, 2019). Smart energy management systems can address the energy consumption and help to change the people behavior in the organizations, leading to improve the energy consumption (Mischos et al., 2023). The EnMS can contribute to minimizing air pollution, carbon footprint, and energy wastage in residential, commercial, and educational buildings (S. Shukla et al., 2023). To improve the integration of environmental behavior into the overall management system of EIs, methodologies and tools such as energy reviews (Escrivá-Escrivá et al., 2019), reporting tools, aggregated indicators, and life cycle assessment have been tested and proposed (Sai et al., 2018). However, existing work lacks a detailed exploration of the simultaneous incorporation of EEnMS. Moreover, a notable gap exists in the establishment of a common practice for implementing EMS in EIs.

In this context, this paper provides the methodology that has served as a guide for incorporating EEnMS in Salesian EIs in Ecuador.

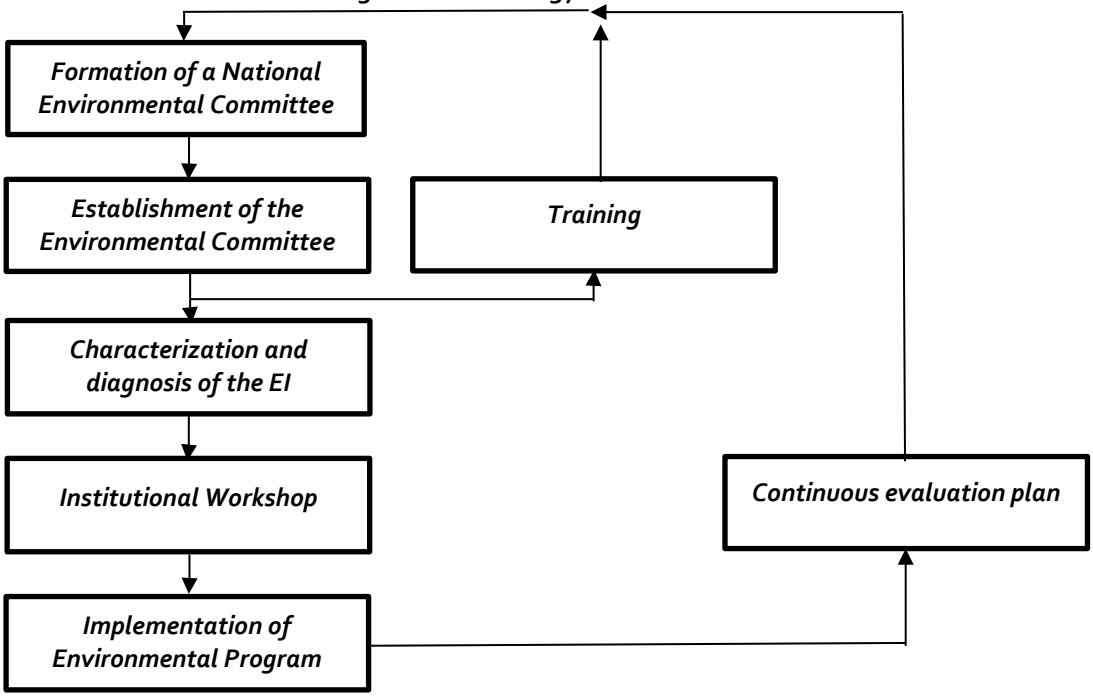
3. Methodology

The implementation process of the EEnMS in the various institutions managed by the Salesian Inspectorate of Ecuador involves the following stages: i) formation of a National

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Environmental Committee (NEC), ii) establishment of an Environmental Committee (EC) in each institution, iii) training of the EC, iv) characterization of the institution and diagnosis of the environmental situation, v) institutional workshop for defining an action plan, vi) development and implementation of an Environmental Program (EP), and vii) creation and execution of a continuous evaluation plan (see Figure 1). The next paragraphs will detail each of the stages.

Fig. 1 – Methodology structure



Source: Own elaboration

3.1 Formation of a National Environmental Committee

The Salesian Inspectorate and the Universidad Politécnica Salesiana (UPS) of Ecuador constitute a NEC composed by the Salesian Inspector (the highest authority of the Salesian Congregation in the country), the Rector, the General Vice-Rector of the UPS, an expert in EMS, an expert in EnMS, and an infrastructure expert. The objective of this NEC is to develop the methodology for implementing the EMS in Salesian EIs in Ecuador. Furthermore, the NEC provides training, advice, and coordinates actions to carry out this implementation.

3.2 Establishment of the EC

Each institution establishes an EC, chaired by the highest authority of the institution or their delegate, and comprises a minimum of three institution members. They are responsible for conducting the diagnosis and managing the implementation and evaluation of the EEnMS.

2024, Editorial Universitat Politècnica de València BY-NC-SA

3.3 Training of the EC

The EC undergoes training on aspects related to EEnMS, conducted by the NEC. This training is the initial step before the start of the process.

3.4 Characterization of the institution and diagnosis of the environmental situation

A detailed description of the activities and processes carried out within the institution is provided, utilizing quantitative data to identify the magnitude of the activities. The diagnosis of the environmental situation of the institution involves selected activities based on the data to be collected. These activities include facility visits, interviews or surveys, such as checklists, process identification, identification of environmental aspects, evaluation of environmental aspects, and an analysis of the current EEnMS of the institution. For this purpose NEC designed a guidance document with the methodology to be followed.

For the initial assessment of the environmental situation of the institution, a checklist of affected environmental factors is created, accompanied by a record of consumption for the previous three years in formats established by the NEC. Five environmental aspects are evaluated: i) water (consumption of drinking water, irrigation), ii) air (emission of gases, noise), iii) energy (lighting, air conditioning, loads, transportation, water heating), iv) solid waste (urban, agricultural, industrial), v) soil (green areas, cultivated areas, reserve areas, vehicular traffic).

3.5 Institutional workshop for the definition of an action plan

Once the diagnosis is completed, each institution's EC understands the strengths and weaknesses regarding the sustainability of their activities. The EC proposes an initial action plan with objectives, activities, and goals for each of the five evaluated environmental factors. A workshop is then conducted involving a significant portion of the educational community, including student representatives from each level. The workshop aims to socialize the institutional diagnosis, improve the action plan proposal, and involve various academic units, collaborators, and students in the defined activities. This way, individuals take ownership of the implementation of the EEnMS.

3.6 Development and implementation of an EP

The institutional EP is structured based on the action plan defined in the workshop. They include the five defined environmental aspects and the most significant actions to improve their management, identifying risks and opportunities. The program should clearly and measurably establish one or more objectives to improve the management of the environmental aspect in question, goals, indicators, measurement methods,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

responsible parties, schedule, budget, and management components. The management components include environmental control, technical control and training. The environmental control focused on administrative tasks, such as measurements, inspections, surveillance, etc. The technical control considers the use of technology, saving devices, among others, and training involves continuous education to achieve awareness and collaboration from staff and users who come to the institution.

The presented activity planning is considered a fundamental input for decision-making by the senior management of the EIs, as it allows a clear assessment of the proposed improvement actions.

3.7 Creation and execution of a continuous evaluation plan:

The EC structures a continuous evaluation plan that allows monitoring the different planned activities that make up the EP. Responsible parties are designated to carry out the monitoring and support. Continuous evaluation of the program allows improvements to be made in each of the activities, ensuring that proposed activities are constantly supervised. The NEC provides the guidelines and formats necessary to carry out this activity.

4. Main Findings

The application of the proposed methodology in different EIs has yielded highly interesting results. Essentially, it has generated enthusiasm within each educational unit, making both good and bad environmental practices visible. Individuals, including students, have committed to and embraced the EP.

The diagnostics carried out have provided a quantitative and qualitative understanding of the management of the five environmental aspects evaluated. Only 15% of the institutions are fully informed about their water consumption, 58% have partial data, meaning they don't know their total consumption, and 27% lack data on water consumption. Concerning energy (electricity and fuels), only 2% of institutions are informed about their total electricity and fuel consumption, 69% have partial data, and 29% lack data about electricity and fuel consumption. Moreover, 98% of institutions have no clear idea about the quantity and types of waste they produce; only 2% have partial knowledge. All institutions lack certainty about the amount of green area on their premises, and 40% have no green areas. Finally, 100% of institutions are uncertain if they produce atmospheric pollution.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Knowledge about resources consumption, waste production and green areas

Aspect	Fully informed [%]	Partial data [%]	Lack data [%]
Water consumption	15	58	27
Energy consumption	2	69	29
Waste production	0	98	2
Green areas quantity	0	100	0
Atmospherc pollution production	0	0	100

Source: Own elaboration

In terms of management practices, such as savings policies, efficient technology incorporation, signage, awareness, recycling, reuse, care of green areas, emission and noise control, etc. Thus, 48% of institutions do not manage water correctly, 50% do so partially, and 2% efficiently. Regarding electricity and fuels, 31% of institutions do not manage them correctly, 69% do so partially, and none manage them entirely efficiently. For waste management, 63% of institutions do not manage it, 33% manage it partially, and 4% manage it efficiently. Concerning green areas, 65% of institutions manage them, 33% do so partially, and 2% efficiently. Finally, 94% of institutions do not manage atmospheric pollution, and only 6% do so partially.

Table 2 – Management about resources

Mangement of:	Efficient [%]	Partial [%]	Inadecuate [%]
Water	2	50	48
Energy	0	69	32
Waste	4	33	63
Green areas	2	33	65
Atmospherc pollution	0	6	94

Source: Own elaboration

In general, proposed improvements by each EI include, changes in technology for energy and water savings, monitoring of air pollution, innovative ideas for waste separation, recycling, reuse, and green area care. Concerning student participation, the EEnMS implementation is in development phase, and we do not yet have clear data about the number of students involved, their impressions, actions and feedback. However, the Salesian EIs in Ecuador which include schools, colleges, and a university, integrate over 50,000 individuals aged between 6 and 24 into their educational service. They operate under a management model geared towards serving the most underprivileged classes, emphasizing subsidiarity, sustainability, and resilience criteria. Consequently, the various curricula will consider the assessment outcomes of this project, as well as any future intervention plans, as models of learning based on

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Participatory Action Research (PAR). PAR fosters the development of a socially and collectively conscious mindset committed to an educational mission that emphasizes the care of individuals and the environment.

Acknowledgements

The authors extend their sincere gratitude to UPS and the Salesian Inspectorate of Ecuador for their logistical and financial support in the development of this work.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Almond, R. E. A., Grooten, M., Juffe Bignoli, D., & Petersen, T. (2020). *Informe Planeta Vivo 2022: hacia una sociedad con la naturaleza en positivo*.

Don Bosco Green Allience. (2024). https://donboscogreen.org/es/

Escrivá-Escrivá, Roldán-Blay, Roldán-Porta, & Serrano-Guerrero. (2019). Occasional Energy Reviews from an External Expert Help to Reduce Building Energy Consumption at a Reduced Cost. *Energies*, *12*(15), 2929. https://doi.org/10.3390/en12152929

Gomes, L. P., Caetano, M. O., Brand, S. M., Dai-Prá, L. B., & Pereira, B. N. (2023). Maintenance of an environmental management system based on ISO 14001 in a Brazilian private university, seeking sustainable development. *International Journal of Sustainability in Higher Education*, *24*(2), 361–381.

Hannah, R. (2019). *Population Growth*. More than 8 out of 10 People in the World Will Live in Asia or Africa by 2100. https://ourworldindata.org/region-population-2100

IPBES, W. (2019). *Intergovernmental science-policy platform on biodiversity and ecosystem services. Summary for Policy Makers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosyst*. IPBES Secretariat, Bonn, Germany.

Lo-Iacono-Ferreira, V. G., Capuz-Rizo, S. F., & Torregrosa-López, J. I. (2018). Key Performance Indicators to optimize the environmental performance of Higher Education Institutions with environmental management system–A case study of Universitat Politècnica de València. *Journal of Cleaner Production*, *178*, 846–865.

Maneesha, Pandey, P. K., & Kumar, S. (2020). Intelligent Energy Information and Management System for Academic Institutes. *In Advances in Solar Power Generation and Energy Harvesting: Select Proceedings of ESPGEH 2019*, 99–108.

Mischos, S., Dalagdi, E., & Vrakas, D. (2023). Intelligent energy management systems: a review. *Artificial Intelligence Review*, 1–40.

O'Keeffe, J. M., Simpson, E., Jorat, M. E., & Vilnay, M. (2020). *Sustainable deployment of environmental management systems for higher education institutions: challenges and*

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

limitations. In University Partnerships for Sustainable Development. Emerald Publishing Limited.

Pesantez-Pesantez, F., Valdez-Salamea, A., Serrano-Guerreo, X., Orozco-Tupacyupanqui, W., & Escriva-Escriva, G. (2017). A digital control system for Lighting Energy Consumption Efficiency (LECE). *2017 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC)*, 1–6. https://doi.org/10.1109/ROPEC.2017.8261640

Roos, N., & Guenther, E. (2020). Sustainability management control systems in higher education institutions from measurement to management. *Journal of Sustainability in Higher Education*, *21*(1), 144–160.

Roos, N., Heinicke, X., Guenther, E., & Guenther, T. W. (2020). The role of environmental management performance in higher education institutions. *Sustainability*, *12*(2), 655.

Sai, S. G., Surya, P., & Gunalan, K. (2018). Smart institutions using energy management system. *4th International Conference on Electrical Energy Systems (ICEES)*, 459–464.

Salesianos Don Bosco. (2024).

Sánchez-Bayo, F., & Wyckhuys, K. A. (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation*, *232*, 8–27.

Serrano-Guerrero, X., & Escrivá-Escrivá, G. (2015). Simulation Model for Energy Integration of Distributed Resources in Buildings. *IEEE Latin America Transactions*, *13*(1), 166–171. https://doi.org/10.1109/TLA.2015.7040644

Serrano, X., Narváez, M., Urigüen, C., & Escrivá, G. (2016). Quantitative Assessment of Hybrid Systems of Heating Domestic Water Based on Solar Energy in Andean Zones of Ecuador. *Power Engineering Conference (UPEC), 2016 51st International Universities*, 1–6.

Shukla, P. R., Skea, J., Calvo Buendia, E., Masson-Delmotte, V., Pörtner, H. O., Roberts, D. C., & Malley, J. (2019). *IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.*

Shukla, S., Jayashree Nivedhitha, V., Shankar, A., Tejaswi, P., & Gnana Swathika, O. V. (2023). Energy Management System for Smart Buildings. *Integrated Green Energy Solutions*, *1*, 327–347.

Tans, P., Keeling, R., Walker, S. J., Piper, S. C., & Bollenbacher, A. F. (2024). *Global CO2 levels*. https://www.co2levels.org/

Zeeshan, M., & Jamil, M. (2019). A Study of Energy Management Techniques for Smart City Applications on Educational Campus. *In International Conference on Communication, Computing and Electronics Systems: Proceedings of ICCCES 2019*, 655–665.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Understanding VET skills needs for enhancing the energy transition

Aleksi Heinonen[a], Martijn Rietbergen[b]

[a]New Energy Research Group, Turku University of Applied Science, Finland

[b]Center of Expertise Smart Sustainable Cities,University ofApplied ScienceUtrecht, TheNetherlands

Abstract

The paper summarizes a skill scan study conducted in the five centers of vocational exelence in the COVE-SEED project: Turku, Utrecht, Bochum, Valencia, and Western Macedonia. This paper reports on a study that aimed at understanding the skills needs in the sustainable energy sector in these regions and how the ongoing energy transition is impacting and will continue to change these needs. The method of this study was structured in three key steps: first, analyzing existing teaching and training programs, second surveying the skills needs of employers, and third analyzing and comparing the results. The main findings of this study are the following. A significant finding from the study is the recognition of development needs, particularly in generic skills. Employers emphasized that technical skills can be acquired more readily through on-the-job training, highlighting the growing need for graduates to apply their technical knowledge effectively in practice. One vital emphasis throughout the study was the importance of improving digital skills, given the rapidly evolving technological landscape in the renewable energy sector. It is important to note that the study has limitations, as it is not a holistic analysis and does not cover all educational institutions in the regions. Additionally, the sample of stakeholders interviewed is relatively small and may not fully represent all perspectives. The study also underlines the influence of specific sample characteristics and the role of particular stakeholders in shaping the highlighted topics. Therefore, these findings should not be overgeneralized, and the unique context of each region should be considered.

Keywords: *energy sector; skills; VET.*

How to cite: Heinonen, A; Rietbergen, M. (2024) Understanding VET skills needs for enhancing the energy transition. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 270-278. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the rapidly evolving European energy landscape, the demand for workforce skills is changing at an unprecedented rate. The skills set of the workfoce deemed important a couple of years ago are probably partly outdated. Therefore curricula in VET schools and Universities of Applied Science should be responsive to these rapid changes; up-to-date skills sets for the energy sector should be incorporated in existing or new curricula. The big questions is however what these new skills are. This paper therefor presents the results of a skills analysis study conducted in five European regions – Turku (Finland), Utrecht (The Netherlands), Bochum (Germany), Valencia (Spain), and Western Macedonia (Greece). These regions participate in the COVE SEED project, see www.coveseed.eu. SEED (Sustainable Energy EDucation) is a CoVE (Centre of Vocational Excellence) program funded by the EU Erasmus+ program. CoVEs are formed by networks of vocational education institutes, industry partners and other organizations to innovate the professional practice and provide high quality vocational skills to young people and adults.

2. Objectives

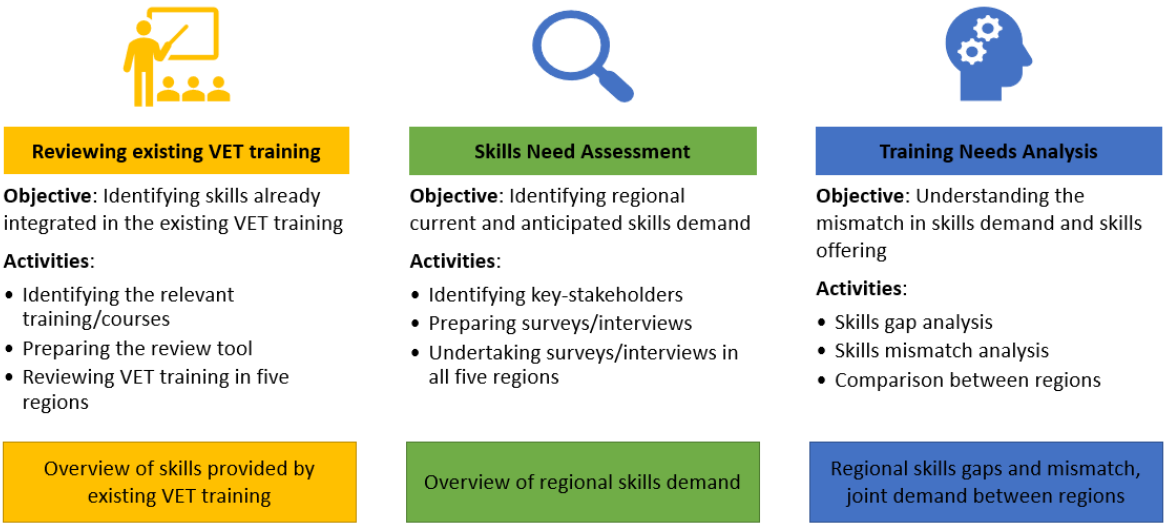
The main objective of the study is to understand the skills required when working in the sustainable energy sector and how education should be developed in each region to match those needs better. More specifically the aim was to understand what kind of skills the current education is providing in each region and then survey regional stakeholders to identify the most important skills, the skills not mastered well, and the anticipated future skills needs. The findings of this study will be used for developing education and other solutions for identifying challenges.

3. Methodology

The skills analysis study is an integral component of the broader skills development process, see in Figure 1. This process comprises three integral stages: 1. Reviewing existing training, 2. Conducting skills needs analysis, and 3. Analyzing the training needs.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Figure 1: The three stages of understanding the skills needs.



Source: Own elaboration

The first stage aims at identifying the skills already integrated in the existing Vocational Education and Training (VET) teaching and training. Each region selected the teaching & training considered relevant in the context of sustainable energy. In total 75 courses or trainings were listed and reviewed. The complete list of reviewed education can be found in Heinonen et al. (2023).

The second stage, representing the core of this paper, aims at identifying regional current and anticipated skills demand. Each region reached out to their existing contacts and tried to reach other relevant stakeholders in sustainable energy in the region as well. Eventually, the skills needs of over 100 employers across the five regions were assessed. The methodology employed a combination of online surveys and interviews to gather insights from these employers. Employers were posed with a set of key questions designed to pinpoint the most critical aspects of their skills requirements, that include:

- Five Most Important Technical Skills (Industry-Related Skills): Employers were asked to identify the top five technical skills crucial to their respective industries. This helped to pinpoint the specific expertise they sought.
- Skills Not Mastered Well: Employers were also tasked with identifying technical skills that were notably lacking among their new recruits or job applicants. This offered insights into areas of improvement and potential training gaps.
- Five Most Important Generic Skills (Soft Skills and Other Cross-Industry Skills): Beyond technical proficiency, employers were queried about the five most vital generic skills. These encompassed soft skills and other cross-industry competencies, contributing to a well-trained workforce.
- Skills Not Mastered Well: Similar to technical skills, employers highlighted the generic skills that were inadequately mastered among their new recruits of job applicants.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Future Skills Needs: Employers were prompted to forecast the skills that they anticipated would be vital in the evolving landscape of the sustainable energy sector. This forward-looking perspective is crucial for skill development planning.
- Proposals for Developing Education: Employers were also encouraged to provide recommendations and suggestions for enhancing educational programs. Their input played a pivotal role in shaping future education initiatives tailored to meet their needs effectively.

In addition to the core questions addressing skills needs, the surveys and interviews also encompassed essential background questions. These inquiries delved into contextual aspects, providing a more comprehensive understanding of the employers' specific situations. Background questions included the company size, recruitment needs, field of industry and relevant energy topics.

The final stage in the skills development process aims at identifying the existing mismatch between the skills demand and the skills currently offered. In a later stage the study results can become instrumental by developing new curricula or course addressing the identified challenges (not reported in this paper).

4. Categorizing skills

In this research we distinguished skills into two main categories: Generic skills and Technical skills. Generic skills encompass transversal and cross-industry skills, while Technical skills pertain to industry or field-specific skills with less applicability across sectors. For the categorization of the generic skills the ESCO Classification for Transversal skills and competences, developed by the European Commission, was employed (European Commission, 2023). This classification system offers a more streamlined and manageable method for categorization. It is structured around 6 main categories, including:

- T1 - core skills and competences
- T2 - thinking skills and competences
- T3 - self-management skills and competences
- T4 - social and communication skills and competences
- T5 - physical and manual skills and competences
- T6 - life skills and competences

For technical skills, own categorization was developed. Categorization consists of field, skill category, and skill level, see Heinonen et al. (2023).

5. Results

This section provides an overview of the results in general level across the regions.

2024, Editorial Universitat Politècnica de València BY-NC-SA

5.1. Conclusions on Generic skills

The analysis of the most important generic skills for employers highlights the need for a wide range of essential abilities, being vital for success in one's career. The most commonly mentioned generic skills across-regions and the corresponding ESCO category have been summarized in the following Table 1.

Table 1 - The most commonly mentioned important generic skills from all regions.

Generic skill	ESCO category
Analytical and Critical Thinking: Ability to analyze complex problems and think critically.	T2.3 - Dealing with problems
Adaptability and Flexibility: Willingness to embrace change and adapt to various situations.	T3.2 - Taking a proactive approach
Effective Communication: Proficiency in verbal and written communication.	T4.1 - Communicating
Collaboration and Teamwork: Ability to work well in diverse teams.	T4.3 - Collaborating in teams and networks
Problem-Solving Skills: Capacity to identify and resolve issues.	T2.3 - Dealing with problems
Curiosity and Continuous Learning: A strong desire to learn and explore new concepts continuously.	T3.4 - Demonstrating willingness to learn
Empathy and Emotional Intelligence: Understanding and connecting with others' emotions.	T4.2 - Supporting others
Innovation and Creativity: Openness to new ideas and creative thinking.	T2.4 - Thinking creatively and innovatively
Responsibility and Ethics: Taking ownership of tasks and adhering to ethical principles.	T3.1 - Working efficiently T4.5 - Following an ethical code of conduct
Digital Literacy and Language Skills: Proficiency in digital tools, technology, and multiple languages for effective communication.	T1.3 - Working with digital devices and applications T4.1 - Communicating T1.1 - Mastering languages

Source: Own elaboration

They include critical thinking, problem-solving, adaptability, and effective communication. Being able to work well in diverse teams is also crucial. Continuous learning and a strong desire to explore new concepts are necessary for personal and professional growth. Understanding and connecting with others' emotions, as well as being open to new ideas and creativity, are key for progress and competitiveness. Responsibility, ethics, and proficiency in digital tools and multiple languages play a role in effective communication and success in today's interconnected professional world. Together, these skills empower individuals to thrive in the dynamic professional landscape.

5.2. Generic skills not mastered well

Employers were also asked which of the important skills are not often well-mastered by the new recruits. The six most common generic skills not mastered well according to the stakeholders from the five regions are listed in Table 2.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 2: The 6 commonly mentioned generic skills not mastered well by new recruits.

Generic skill	ESCO category
Lack of effective communication, including clear writing and verbal communication skills.	T4.1 - Communicating
Challenges in teamwork, collaboration, and adaptability, especially among senior profiles.	T4.2 - Supporting others T4.3 - Collaborating in teams and networks T3.2 - Taking a proactive approach
Limited ability to think critically and solve problems.	T2.1 - Processing information, ideas, and concepts T2.3 - Dealing with problems
Insufficient leadership and organizational skills.	T4.4 - Leading others T2.2 - Planning and organising
Difficulty in time management and planning.	T2.2 - Planning and organising T3.1 - Working efficiently
Insufficient interpersonal skills, including empathy, tolerance to frustration, and confidence.	T4.2 - Supporting others T4.5 - Following an ethical code of conduct T3.3 - Maintaining a positive attitude

Source: Own elaboration

The study identifies several key areas where skills improvement is needed, including enhanced communication, teamwork, adaptability, critical thinking, leadership, time management, and interpersonal skills. These findings underscore the importance of addressing these skill gaps to bolster professional success and effectiveness across various profiles.

5.3. Conclusions on Technical skills

When we examine the most important technical skills valued by employers, it's clear that a diverse range of technical skills is essential for professional success. The results indicate a noticeable emphasis on certain fields within sustainable energy, which is due the focus areas of regional industries and the potential bias in the survey respondents. Additionally, it's worth noting that some skills labeled as technical by employers were, in fact, generic skills, for example in the realm of communication. This echoes the significance of robust generic skills as perceived by employers. These are the most commonly mentioned technical skills by employers:

- ICT Skills: Proficiency in information and communication technology.
- Data Analysis: Proficiency in analyzing data for decision-making.
- Smart Structures: Understanding and working with smart building structures.
- Air Treatment: Knowledge of air quality and treatment methods.
- Applied Physics: Applying principles of physics to practical situations.
- Automation Technology: Expertise in automation systems and technologies.
- Cooling Techniques: Ability to work with cooling methods.
- BIM (Building Information Modeling): Using digital building models for design and planning.
- Energy Installations: Designing and analyzing energy systems.
- Regulatory Compliance: Understanding and adhering to industry regulations.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

5.4. Technical skills not mastered well

Employers have identified several technical skills that are often lacking in new recruits. Many of the listed deficiencies overlap with the skills identified as important. Therefore, it can be inferred that a significant portion of the skills perceived as important are inadequately possessed by new employees and job applicants. Proficiency in information and communication technology (ICT) is essential, yet newcomers often struggle in this area. Understanding and working with smart building structures, managing air quality and treatment methods, and applying physics principles are also areas where competence is frequently lacking. Expertise in automation systems, cooling methods, and the effective use of Building Information Modeling (BIM) for design and planning are in high demand but underdeveloped in new recruits. Additionally, skills in designing and analyzing energy systems, understanding and adhering to industry regulations, and data analysis for decision-making are increasingly crucial. Addressing these skill gaps is essential to bridge the gap between theoretical knowledge and practical application, meeting the evolving demands of modern industries. These are the skills mentioned by employers that are not mastered well:

- Specialized knowledge in areas like bioenergy, high voltage installation, and photovoltaic components.
- Project management skills
- Digitalization skills, including emerging technologies such as VR and AR.
- Understanding of energy market dynamics and associated tools for effective decision-making.
- Knowledge of specific software and regulations in the field.
- Technical expertise in areas like control techniques, integrated engineering, and sustainable energy sources.

5.5. Skills needed in the future

Employers were also questioned about the future skills requirements within their companies or fields. It was observed that many of the skills identified were repetitive or related to areas where proficiency was lacking. Foreseeing the skills required in the future can be challenging for companies, but some respondents managed to pinpoint these skills. Notably, the list emphasized technical skills, with comparatively less focus on the evolution of generic skills. These skills include:

- Data Science and Analytics (Data analysis, ML, statistics, cybersecurity)
- Renewable Energy Technologies (Geothermal, aerothermal, hydrogen)
- IoT and AI (Internet of Things, Artificial Intelligence)
- Digitalization (VR, AR, digital tools)
- Electric Vehicle (EV) Infrastructure
- CO_2 Management and Environmental Laws
- SCADA Programming (Renewable energy projects)
- Electronics and Electrical Engineering (High-voltage installations)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

6. Limitations

It is important to consider several key aspects of this study. To begin, the research was conducted exclusively in five specific regions, with a focus on curricula from CoVE-SEED partners and courses relevant to the energy sector. The companies surveyed represent only a limited cross-section of the industry, with the possibility that those having previous collaborations with universities were overrepresented due to their greater willingness to participate. Categorization methods used in the study presented challenges, as interpretations varied among different individuals and regions, often deeming the categories vague or overlapping. Consequently, the category-based analysis had more limitations than anticipated. While the findings should be viewed as indicative and not overly generalized, they do reveal discernible trends and offer insights into regional development points. In summary, this study, while not without limitations, provides valuable insights within its defined scope, which is essential to consider when drawing conclusions and making recommendations based on its results. In conclusion, despite the limitations with categorization and the constraints of a relatively small sample size of teaching & training and employers, this study has yielded valuable insights on skills needed when working in the field of sustainable energy.

7. Conclusions

Across the regions, valuable insights and common challenges have emerged, offering a wealth of lessons to enhance skills training and education in the dynamic sustainable energy sector. These insights highlight the following key aspects:

- Soft Skills Emphasis: Regions universally recognize the significance of soft skills as integral to education and personal growth, emphasizing their role in fostering adaptable and well-rounded individuals.
- Digital Proficiency: A shared awareness of the increasing importance of digital skills underscores the need for best practices in incorporating digital literacy and technology integration into training programs to meet the demands of the digital age.
- Industry-Academia Collaboration: The value of strong collaborations between educational institutions and industry partners is a common theme, with each region presenting its unique model of successful collaboration, which can guide other areas in aligning training with the ever-evolving needs of the industry.
- Technical Expertise: Acknowledging the paramount need for technical competencies, especially in fields like engineering, reinforces the commitment to offering effective technical training that keeps pace with emerging technologies.
- Flexibility and Practical Experience: A shared conviction of the value of flexibility and practical experience in training underscores the need to exchange approaches for integrating theory with real-world practice, enhancing the quality of education.

2024, Editorial Universitat Politècnica de València BY-NC-SA

- Specialization: Several regions highlight the need for specialized training in areas such as renewable energy and hydrogen technology. Sharing methods for offering specialized programs can meet specific demands of the sustainable energy sector.
- Valuing Adaptability: Regions collectively acknowledge the unpredictability of the labor market and the necessity of preparing students for rapid changes. This shared perspective can guide the development of adaptability-focused programs.
- Human-Centered Skills: The emphasis on human-centered, value-based leadership and soft skills as a common thread can guide regions in developing strategies for personal and professional growth through the development of these skills.

In summary, these shared findings and lessons underscore the importance of fostering adaptability, integrating soft skills, staying current with industry trends, and aligning programs with the demands of the sustainable energy sector. Collaboration and the exchange of best practices can benefit all regions in their efforts to cultivate a skilled, adaptable, and future-ready workforce.

The findings from this study offer a valuable starting point for addressing regional needs and challenges and for establishing Centers of Vocational Excellence (COVEs) within the sustainable energy sector. It is still important to continue the analysis of skills needs in collaboration with stakeholders within SEED. The energy transition is advancing rapidly, and the skills needs are continually evolving. Thus, ensuring alignment with industry needs must become a sustainable and agile part of COVEs to be established.

Acknowledgements

This research has been funded by the European Union - EU Solidarity Corps under grant agreement No 101056147 as part of the ERASMUS+ COVE-SEED project (www.coveseed.eu).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Heinonen, A. J. Jongen, E-M. Kempe, E. Mantela, E. de la Poza-Plaza (2023). SEED Skills Analysis Report. Shaping Skills for Energy Transition in five European Regions. Deliverable from the COVE-SEED project.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Zero Time, Zero Investment: Innovative Strategies for Sustainable Energy Development in Underdeveloped Countries

Aleena Ahmad[a], Kiran Siraj[a], Malik Muhammad Arslan[a], Hafiz Owais Ahmad Khan[a], Naveed Arshad[a]

[a]Department of Computer Science, Syed Babar Ali School, of Science and Engineering, Lahore University of Management Sciences, Lahore 54792, Pakistan

Abstract

The sustainability of the energy sector in Pakistan is hindered by many factors such as the difference in demand and supply, poor economic situation, unviable customer tariffs, the ever-lasting circular debt, low recoveries, futile subsidy framework for gas, and poor implementation of policies. The growing circular debt has surged to almost USD 19.1 billion and is significantly contributed by the power, petroleum, and gas sectors, subtotaling USD 10.12 billion, USD 2.66 billion, and USD 6.22 billion, respectively. Reducing this significant financial strain on the national exchequer and tackling additional inefficiencies require various interventions. Many of these initiatives require a significant investment of time and money, which is difficult given the precarious state of the nation's economy. However, certain impactful policies can be taken in zero time and require zero to minimal investment to partially alleviate the financial burden of the energy sector. This paper provides a thorough qualitative and quantitative analysis of a spectrum of interventions in the energy sector that can be executed instantly with zero to minimal financial investment. Based on our calculations, the suggested adjustments may result in savings of about USD 2.22 billion per year. While acknowledging the need for a comprehensive, long-term strategy to revamp the energy sector over the years, we view these interventions as a crucial 'first aid'. These measures offer immediate relief, effectively addressing a noticeable financial burden and laying the groundwork for more extensive, sustained reforms in the future.

Keywords: circular debt; energy sustainability; policies; financial investments; interventions.

How to cite: Ahmad, A.; Siraj, K.; Malik M. A.; Ahmad Khana, H.O. and Arshada, N. (2024) Zero Time, Zero Investment: Innovative Strategies for Sustainable Energy Development in Underdeveloped Countries. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 279-289.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Energy reforms play a crucial part in national development policies, globally. Being the nexus of pivotal transformation, the energy sector highlights the intricate issues related to economic growth, energy inefficiency, climate change, and sustainable resource utilization. Under these circumstances, the Grand National Dialogue on Energy Reforms becomes an important forum intended to discuss, plan, and steer the direction of significant changes in the energy sector. Moreover, these initiatives provide a roadmap for the implementation of National Determined Contributions (NDCs) and Sustainable Development Goals (SDGs), which are the backbone of national sustainable development. Due to the wider perspectives of these initiatives, we suggest a globally used practice of blending transdisciplinary research and transition management principles (Noboa & Paoul, 2018). Although, academic institutions can play a substantial role in the success of theoretical projects while policy sector has the expertise of real-world challenges (Zilahy, Donald, Melanen, D. Phillips, & Sheffy, 2009). The amalgamation of these two will result in the practical applications of academic research to address the policy issues and challenges more constructively, and in a balanced manner (Zilahy & Donald, The Roles of Academia in Regional Sustainability Initiatives, 2009).

Being a developing nation, Pakistan's energy sector grapples with significant challenges such as circular debt, excessive generation capacity, depletion of energy resources, mismanagement, and heavy reliance on imports.

Currently, the circular debt in the power sector has reached USD 9.94 billion (NEPRA, 2022). This debt is primarily composed of over-capacity, capacity payments, electricity theft, poor recoveries, and transmission and dispatch (T&D) losses, among other contributing factors. The power sector of Pakistan has an installed capacity of 206 TWh, however, only 143 TWh of that capacity has been utilized (NEPRA, 2022). This discrepancy between installed and utilized capacity leads to a significant amount of circular debt that is expanding annually.

Furthermore, Pakistan's energy sector is also experiencing a depletion of its natural gas resources, as the country has been consuming more than it produces, leading to a rapid decaying of its gas reserves. The current shortfall rate of gas is 1.44 BCF according to the Oil and Gas Regulatory Authority, which is expected to grow to 5.4 BCF by the end of this decade. At the current production rate of 1.5 TCF, the proven gas reserves of around 19 TCF are expected to last for 13 to 14 years, barring any discoveries (OGRA, 2021-22). The lack of oversight in the gas distribution infrastructure contributes to both direct losses and escalating circular debt, reaching a staggering USD 6.1 billion, according to the financial figures reported in the balance sheets of (PPL), 2022) and (OGDCL, 2022). On the other hand, higher levels of pollutants in indoor, outdoor, and building environments stem from gas consumption and methane leaks, resulting in various health issues such as cardiovascular and respiratory disorders, with a notable impact on women and children.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Moreover, the petroleum sector is also facing insufficient resources as well as inefficient infrastructure for refining petroleum products. Therefore, 80% of demand in the petroleum sector depends on imported resources to meet the country's requirements. It caused a hefty burden of USD 23 Billion in import bills during the FY 2022 (Tahir, 2023). In addition to that, other issues like port congestion and the absence of night navigation in ports create extra delays and increase the cost of fuel.

To this end, we have formulated a policy framework for the energy sector designed to provide guidance and steer the trajectory of underdeveloped countries. This framework is aligned with NDCs and SDGs, and it employs a streamlined approach to ensure efficient and effective implementation (Soergel, et al., 2021). However, numerous interventions demand substantial time and financial resources, which are not feasible given the fragile economic conditions of the country. Nonetheless, some impactful measures, requiring zero time and zero investment can be implemented immediately. These guidelines embody actions that are economically viable, socially equitable, and environmentally responsible.

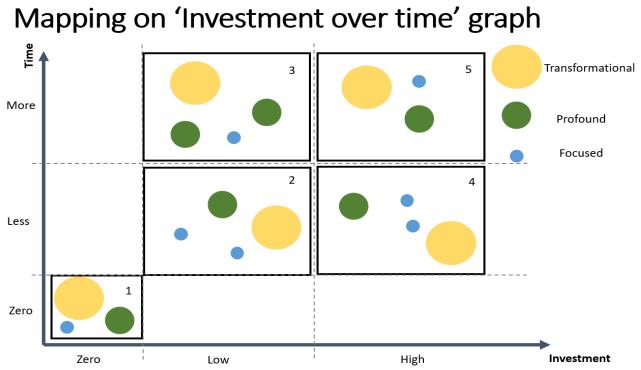
2. Potential Interventions in the Energy Sector

There exists a broad spectrum of both quantifiable and non-quantifiable interventions that are vital in formulating sustainable energy policies and guiding decision-making processes. **Quantifiable Interventions** depend on high-granularity data, reliable sources of information, cost models, correlations, and sound assumptions which provide evidence-based and data-driven methods that offer a strong basis for strategic planning. While **Non-Quantifiable** or **Qualitative Interventions** encompass the professional judgment derived from global experiences and common sense. The synergy between quantitative and qualitative elements ensures a comprehensive and adaptable approach to complex challenges.

Adopting energy-efficient technologies, supporting renewable energy sources, improving grid infrastructure, putting demand-side management strategies into practice, offering incentives for energy conservation, raising public awareness of sustainable energy use, organizational efficiency, indigenous industrial reforms, imports reduction and encouraging funding for clean energy research and development are some potential interventions in the energy sector. The interventions according to their impact can be divided into three types; **Transformational, Profound, and Focused** respectively, according to their gradual ranked status. We have also mapped them into an "investment over time graph" to show the 5 variants based on time and investment.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1- Investment over Time Graph for Potential Interventions



Source: Own elaboration

"**Investment over time**" refers to a range of scenarios that specify how much money and time are needed to undertake initiatives. These possibilities range from taking quick action with little financial outlay to making lengthy attempts that require significant outlays of funds. The **"zero time, zero investment"** scenario allows for the quick implementation of initiatives without requiring large time or cost investments. On the other hand, the **"high time, high investment"** scenario calls for significant financial outlays as well as protracted implementation times. In between these two extremes are situations like **"high time, low investment"** and **"less time, low investment,"** which take resource limits into account while prioritizing timeliness or cost-effectiveness, respectively. Policymakers can better customize policies to accomplish specific objectives while optimizing resource allocation by offering a detailed analysis across these scenarios.

3. Methodology

The verification process involved several key steps. Initially, a list of interventions aimed at addressing energy challenges was compiled. These interventions underwent a rigorous technical evaluation to assess their potential impact on energy problems and their economic viability. Once interventions were deemed technically approved and economically viable, they were added to a final showcasing list. Subsequently, this finalized list of interventions was presented to more than 30 experts[1] from various public and private organizations within the energy sector. Each intervention was thoroughly discussed, and feedback and comments were gathered from the experts. Following this extensive consultation process, 13 interventions were selected to be included in a scenario of zero-time, zero-investment. This scenario implies that the government would only need to issue a notification to implement these interventions, resulting in potential savings of millions of dollars annually. This

[1] Experts List for Grand National Dialogue

BY-NC-SA

methodology ensured that the proposed interventions underwent comprehensive technical evaluation and expert scrutiny, ultimately leading to the identification of impactful, cost-effective solutions for addressing energy challenges in developing countries.

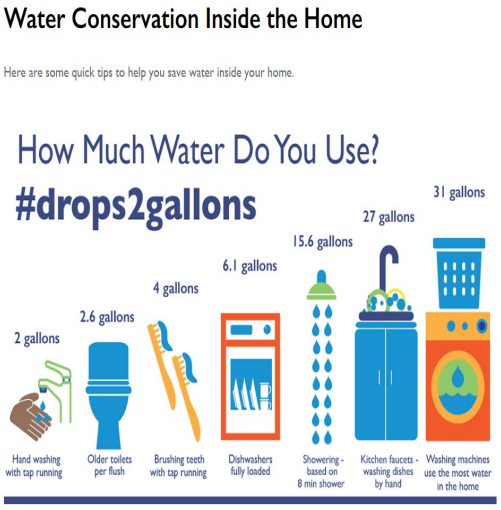
4. Navigating Challenges with Zero Time and Zero Investment

The interventions presented in this study address the energy sector challenges through some quick and mostly painless measures that reside in the "zero time, zero investment" category.

4.1 Nudging Towards Energy and Water Conservation

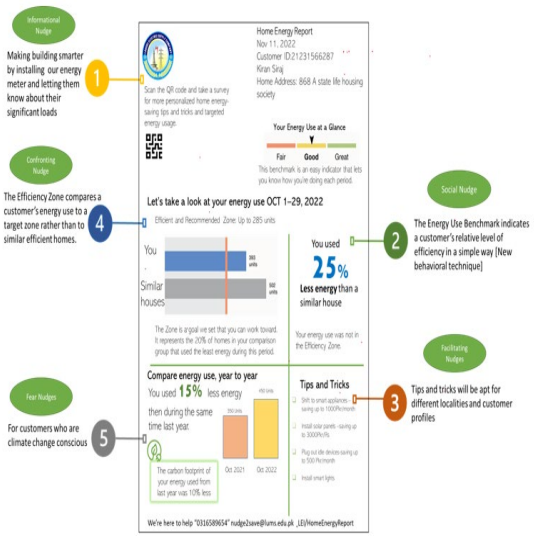
Subtle nudges and awareness campaigns can influence communities to adopt more sustainable practices. According to our estimates, the impact due to nudging can potentially save USD 600 million annually. Some examples of nudges the energy sector can adopt through the means of gas and electricity bills are detailed in Figures 2 and 3. Moreover, Figure 3 created by the author illustrates a hypothetical draft of an advanced billing system designed to demonstrate different possible nudges on an electricity bill.

Fig. 2- Water conservation Nudges



Source: (Water, 23)

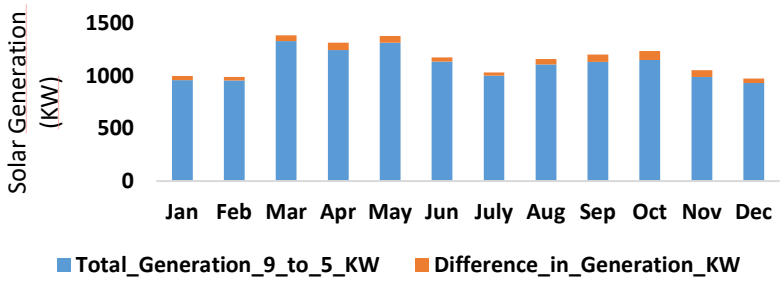
Fig. 3- Possible Nudges on an Electricity Bill



BY-NC-SA 2024, Editorial Universitat Politècnica de València

4.2 Permanent Daylight Saving Time (DST)

Fig. 4- Difference in solar generation from 9am-5pm (in blue) vs. 8am-4pm (in orange)



Source: Own elaboration

Shifting Pakistan's current time zone from UTC+5 to UTC+6 throughout the year can result in a reduction of energy consumption by 932 GWh, translating into a saving of USD 446.8 million annually. Given Pakistan's tropical location, a permanent DST would mean daylight during all office hours. Figure 4 depicts the annual solar energy generation between 8am to 9 am is 16% higher than the generation between 4pm to 5pm making more clean electricity available for office utilization if the shift is adapted ((NREL), n.d.). Moreover, the lighting needs will be an hour later throughout the year which would result in another saving worth of USD 30 million.

4.3 Shifting Weekly Holiday from Sunday to Friday

The energy demand profile of Pakistan shows that Friday is the least productive of the working days. Essentially the energy usage in the country drops significantly around mid-day and does not recover back, indicating a massive drop in productivity. As per our calculations and estimates, if Sunday is declared as a working day and Friday as a weekly holiday, productive energy consumption can increase by 771 GWh in a year, resulting in a GDP growth of almost USD 433 million annually.

4.4 Reduction in WACG through Demand-side Tariff Management

Shifting the electricity load to off-peak hours through demand-side tariff management or time-of-use pricing can result in a reduction of Weight Average Cost of Generation (WACG) (Hafiz Owais, Muhammad Usman, Ahmad, & Naveed, 2022). Calculations presented in Table 1 below depict that a mere 5% shifting of load from peak to off-peak hours can result in total savings of USD 348 million annually (NEPRA, 2022).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 Energy Generation Cost Savings by Shifting 5% load from Peak to Off-Peak Hours

Months	Energy Cost (Billion Rs/GWh)	Energy Cost with 5% Adjustment (Billion Rs/GWh)	Savings (Million USD)
July	68.1	59.2	39.1
August	64.4	55.6	38.8
September	57.9	50.12	34.8
October	48.3	42.28	27.1
November	27.4	22.95	19.7
December	50.5	45.80	20.7
January	55.3	50.86	19,7
February	36.4	32.03	19.3
March	52.05	46.71	23.7
April	62.2	55.10	31.6
May	78.2	70.47	34.4
June	87.2	78.63	38.1
TOTAL			**348.2**

Source: Own elaboration

4.5 Interventions in Domestic Gas Load Management Policy

The domestic sector consumes 425 MMFCD of heating load during peak winter months, which generates revenue of around 97.6 million USD annually. However, redirecting this gas to the industrial or power sector by revising the National Gas Allocation and Management Policy could yield annual revenues of USD 294 million or USD 239 million, respectively. We surveyed to collect 60,000 Bills of SNGPL (SNGPL, n.d.) Users and performed analysis to get this heating Load number.

4.6 Change in Commercial Activity Time

Limiting the time of commercial activity from 9 am-7 pm can potentially save USD 48 million annually in the form of commercial load reduction (NEPRA, 2022).

4.7 Electricity and Gas Bill Page Size Reduction

Based upon calculations by other relevant entities, a size reduction in the size of the billing page from A4 to A5, sent monthly to 33.2 million customers has the potential to save USD 15.5 million annually on paper import according to (SBP, 2022), (Statistics, n.d.)

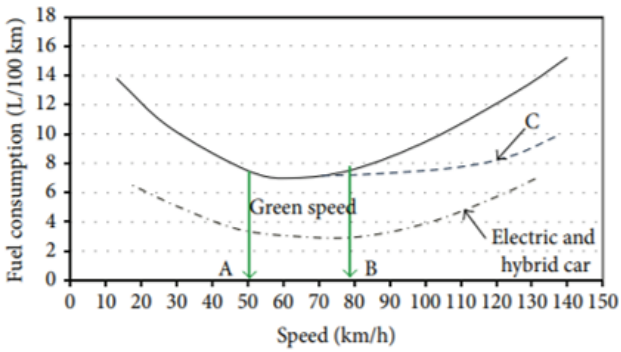
BY-NC-SA 2024, Editorial Universitat Politècnica de València

4.8 Utilization of Hydel Generation to Address Intermittency from Renewables

Currently, the Indus River System Authority (IRSA, n.d.) provides a 24-hour quantity of water reserves to the dams and (NPCC, n.d.) decides the hourly release amount of the water based on the electricity demand. Employment of hydel sources for rapidly ramping up generation to meet the demand can result in a substantial reduction in the Weighted Average Cost of Generation (WACG) (Hafiz Owais, Aleena, Ahmad, & Naveed, 2023)and potentially save USD 13.2 million annually.

4.9 Reducing Vehicular Speed Limit on Motorways (Case: M-2)

Fig. 5-Fuel consumption compared to the speed of vehicles



Source: Own elaboration

The petroleum imports of Pakistan have been surging double-digits in percentage for the past few years (OGRA, 2021-22). Reducing the maximum speed limit on motorways from 120 km/h to 100 km/h can potentially save USD 6.32 million annually on petroleum imports. Fuel consumption of vehicles decreases with increasing speed, after an optimal range, labeled in Fig 5 as "Green Speed", is reached, after which the consumption continuously increases. Label "C" shows a trend for very low aerodynamic resistance.

4.10 True Peak Hours

Adjusting peak hours and corresponding tariffs periodically according to the national electricity demand profile can save USD 6.34 million annually. (NTDC, n.d.)

4.11 Solar Net Metering

Surplus energy generated by rooftop solar PV installations can be utilized as a source of affordable generation by electricity distribution companies (DICSOs), a phenomenon typically associated with higher solar PV penetration in the residential sector. Tight solar feed-in restrictions risk customer grid defection, necessitating a balanced strategy that utilizes residential solar energy as a Distribution Companies (DISCOs) power source. Shifting

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

to a generation-following tariff could also mitigate the duck curve's effects (Calero, Cañizares, Bhattacharya, & Baldick, 2021).

4.12 Bringing Captive Generation to the Grid

Around 5000 MW of power is generated in Pakistan through captive generation. Industrial units are allowed to install their captive power plants to produce electricity for their use. However, the installed captive units have an efficiency of around 25-30%, which is much lower than the power plant installed having an efficiency of 50-60%. In the year 2020, captive power units consumed 415 MMCFD of gas. Shifting captive generation-based industry to the national grid can improve the energy usage for the grid and will help increase the base load for the grid (CPPA, 2021-22).

5. Implementation Strategies

While our paper predominantly delves into innovative strategies for sustainable energy development in developing countries, we recognize the pivotal role of education in advancing this field. Dissemination of knowledge catalyzes raising awareness, fostering understanding, and empowering individuals and communities to embrace sustainable energy practices. Through a Grand National Dialogue, we incorporated discussions on the role of education in promoting sustainable energy development, emphasizing the significance of educational initiatives, training programs, and knowledge-sharing platforms in driving progress toward sustainability goals. The (LUMS, Rausing Executive Development Centre, n.d.) offers executive-level learning solutions through both open and customized programs. Additionally, numerous initiatives aimed at capacity development within government sector entities, such as (NTDC, n.d.) and DISCOs, highlight our essential contribution to policy frameworks. In LUMS, multiple workshops and training programs on energy practices and sustainable energy policies engage different stakeholders effectively and serve as a pathway for implementing research findings and advocating for proposed solutions. Public awareness campaigns further amplify our efforts to educate communities and influence positive behavioral changes. Moreover, our establishment of knowledge-sharing platforms like online portals and forums, including (LUMS, LUMS X, n.d.), and (NCBC, n.d.), facilitates collaboration and dissemination of insights within the energy sector. By providing a centralized space for knowledge exchange, we strive to facilitate informed decision-making, foster innovation, and drive collective action toward sustainable energy development.

6. Conclusion

While a comprehensive transformation of the energy sector requires a long-term strategy, these measures can act as immediate 'first aid,' effectively alleviating a noticeable financial burden. The impacts span various areas, encompassing energy and organizational efficiency,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

productive energy use, industrial productivity enhancement, renewable energy utilization, import reduction, and curtailed socio-economic costs due to emissions reduction. Collectively, these quantifiable interventions present a substantial annual financial impact of $2.22 billion annually.

Acknowledgments

This study expresses heartfelt gratitude to IPRI for their invaluable support in developing this paper. Additionally, the study extends appreciation to (LUMS) for their support and resources that contributed significantly to the research and writing process.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

(NREL), N. R. (n.d.). PVWatts® Calculator. Retrieved from NREL: https://pvwatts.nrel.gov/

Calero, I., Cañizares, C. A., Bhattacharya, K., & Baldick, R. (2021). Duck-Curve Mitigation in Power Grids With High Penetration of PV Generation. IEEE Transactions on Smart Grid, 314 - 329.

CPPA, C. P. (2021-22). Harnessing Indigenous Resources for Affordable Electricity. CPPA.

Hafiz Owais, A. K., Aleena, A., Ahmad, N., & Naveed, A. (2023). Lowering Weighted Average Cost of Generation by Optimizing Operating Time: A Study from Pakistan. 2023 1st International Conference on Advanced Innovations in Smart Cities (ICAISC), (pp. 1-6). Jeddah.

Hafiz Owais, A. K., Muhammad Usman, T., Ahmad, A., & Naveed, A. (2022). Reduction in Weighted Average Cost of Generation by Utilizing ToU Pricing Models: A Study from Pakistan. 2022 11th International Conference on Renewable Energy Research and Application (ICRERA), (pp. 119-124). Istanbul.

HEC, H. E. (2018). NCBC. Retrieved from The National Center of Big Data & Cloud Computing : https://ncbc.pk/

IRSA, I. R. (n.d.). IRSA Home. Retrieved from IRSA: http://pakirsa.gov.pk/

LUMS, L. U. (n.d.). LUMS X. Retrieved from LUMS X: https://lumsx.lums.edu.pk/

LUMS, L. U. (n.d.). Rausing Executive Development Centre. Retrieved from Rausing Executive Development Centre: https://redc.lums.edu.pk/

NCBC. (n.d.). National Center in Big Data and Cloud Computing. Retrieved from NCBC: https://ncbc.pk/

NEPRA. (2022). State of Industry Report 2022. Islamabad: NEPRA.

Noboa, E., & Paoul, U. (2018, December). Energy policy and transdisciplinary transition management arenas in illiberal democracies: A conceptual framework. Energy Research & Social Science, 114-124. Retrieved from https://doi.org/10.1016/j.erss.2018.07.014

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

NPCC. (n.d.). NPCC, National Power Construction Corporation . Retrieved from NPCC, National Power Construction Corporation : https://www.npcc.com.pk/

NTDC, N. T. (n.d.). National Transmission and Distribution Company. Retrieved from NTDC: https://ntdc.gov.pk/

OGDCL, O. a. (2022). Annual Report 2022 (Hum Hain Pakistan). Islamabad: OGDCL.

OGRA. (2021-22). Petroleum Industry Report. OGRA.

PPL), P. P. (2022). Annual Report 2022. Karachi: PPL.

SBP, S. B. (2022). Annual Report, The State of Pakistan's Economy. State Bank of Pakistan.

SNGPL, S. N. (n.d.). Sui Northern Gas Pipelines Limited. Retrieved from Sui Northern Gas Pipelines Limited: https://www.sngpl.com.pk/#

Soergel, B., Kriegler, E., Weindl, I., Rauner, S., Dirnaichner, A., Ruhe, C., . . . Popp, A. (2021, June). A sustainable development pathway for climate action within the UN 2030 Agenda. Nature Climate Change, 656–664. Retrieved from https://doi.org/10.1038/s41558-021-01098-3

Statistics, P. B. (n.d.). Pakistan Bureau of Statistics. Retrieved from Pakistan Bureau of Statistics: https://www.pbs.gov.pk/

Tahir, A. (2023, July 19). FY 2022-23: Petroleum group imports show negative growth. Business Recorder. Retrieved from https://www.brecorder.com/news/4025362#:~:text=ISLAMABAD%3A%20Petroleum%20group%20imports%20witnessed,Bureau%20of%20Statistics%20(PBS).

Water, W. (23, August 31). Conservation. Retrieved from WSSCWater: https://www.wsscwater.com/conservation

Zilahy, G., & Donald, H. (2009). The Roles of Academia in Regional Sustainability Initiatives. Journal of Cleaner Production, 1057-1066. Retrieved from https://doi.org/10.1016/j.jclepro.2009.03.018

Zilahy, G., Donald, H., Melanen, M., D. Phillips, V., & Sheffy, J. (2009). Roles of academia in regional sustainability initiatives: outreach for a more sustainable future. Journal of Cleaner Production, 1053-1056. Retrieved from https://doi.org/10.1016/j.jclepro.2009.03.006

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Sustainable Mobility

Carlos Hernandez Vicente, Carlos Llorca Jerez, Matías Sánchez García, Mercedes Llorens Nicolau, Daniel Francés Belda

Cipfp Canastell, Fam. Profesional de Transporte y Mantenimiento de Vehículos y Fam. Profesional de Instalación y Mantenimiento. Alicante, Spain

Abstract

Disruptive learning process as a motivating and responsible element with the students' own learning process.

Vocational Training School will develop an urban and interurban mobility vehicle adapted to people with reduced mobility in which it is possible the **direct coupling** of its personal mobility system. The propulsion system will be **electric with a hydrogen cell and supercapacitor battery** for short high-power recharging.

In order to develop the vehicle, the association **AMFI of Elda (Alicante) and others in the surrounding area** of the educational institution will cooperate. Our vocational training school takes part in different open collaborations such as the "Augmented Mobility" project in which our students provide an advisory and technical service for users of electric wheelchairs and research for updating batteries to more cutting-edge technologies and devices that allow features such as remote diagnosis, geolocation, adapted control, etc.

This project is part of an Intercentre project for grouping centres in which each centre will develop its own vehicle to share processes, solutions and difficulties. The project of grouping of centres contemplates the mobility and sharing by the students of the different centres, as well as visits to institutions (National Hydrogen Center, Institute of Electrochemistry of the University of Alicante, etc.), meetings of coordination and transfer of knowledge among the students of the centres.



How to cite: Hernandez Vicente, C.; Llorca Jerez, C. and Sánchez García, M. (2024) Sustainable Mobility. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 290-296.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the field of Vocational Training, due to origin and vocation, our centre has always stood out as a reference centre in the region, adapting over the years to successive educational Law reforms such as the experimental Vocational Training Courses (1988/89), the **LOGSE Vocational Training Cycles** (1994/95), the Social Guarantee Programmes (1999/200) and the following **Initial Professional Qualification Programmes - PCPI** (2007/2008) and the new **LOE cycles** starting from the 2009/10 academic year. It should be pointed out that our integration and commitment with the work environment by means of teaching a significant number of Non-Regulated Vocational Training courses (**Training for Employment and Professional Certificates**)

Since 2007 our new trajectory begins as a **Public Integrated Vocational Training Centre**. Currently, Basic Qualification training programmes, Programmes for Special Education students as well as Intermediate and Higher Vocational Education and Training cycles (VET and HNC) of the following professional families. Indeed, they are taught to an average of approximately 1700 to 1900 students.

.- Electricity and Electronics
.- **Vehicle Transportation and Maintenance (Autonomous Reference Centre)**
.- Security and Environment
.- Cookery, Catering and Tourism
.- Health
.- Sociocultural Services to the Community
.- Installation and Maintenance

2.- The project

The imminent transformation of the automobile sector towards sustainable mobility makes it inherent to adapt our Vocational Training teachings to the cutting-edge technologies used in vehicle propulsion. For this reason, it has been considered appropriate to develop a multidisciplinary project consisting of the manufacturing of a sustainable vehicle by each educational centre involved, using different technologies for its propulsion.

Vocational Training School will develop an urban and interurban mobility vehicle **adapted to people with reduced mobility** in which **direct coupling** is possible for its personal mobility system. The propulsion system will be electric with a hydrogen cell and supercapacitor battery for short high-power recharging.

To develop the vehicle, the association **AMFI of Elda (Alicante) and others in the surrounding area** of the educational institution will cooperate. Our vocational training school takes part in different open collaborations such as the "Augmented Mobility" project in which our students provide an advisory and technical service for users of electric wheelchairs and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

research for updating batteries to more cutting-edge technologies and devices that allow features such as remote diagnosis, geolocation, adapted control, etc.

This project addresses a multitude of competencies included in the curriculum or guidelines of the training cycles and specialization courses of the Vocational School participating students.

The lack of an offer for sustainable mobility in the field of people with reduced mobility, as well as the increase in this group for **aging population reasons**, makes it necessary to create a wider range of systems that can make mobility easier. Furthermore, there is a **significant deficit in technical advisory and service** repair and assistance for users of current means of mobility in this sector. Including this problem in the contents and tasks of our students would provide an almost non-existent offer of specialized technicians, as well as new mobility solutions in this sector.

2.1. Objectives

1.-Setting up an educational network that allows, through visits and mobility between our centres, the establishment of links and the development of close collaboration. This will allow us to improve the results and the perspective of solutions in the projects to be developed that are based on an area of common interest such as the development of vehicles and technologies linked to sustainable mobility. This will convey searching for optimal solutions adapted to the capacities and resources available in the Vocational centres.

2.-Fostering communication and facilitating the students' personal development, bolstering the growth of social skills and interpersonal relationships, through visits to the Vocational centres and the exchange of information about their projects.

3.-Solving and/or improving the current lack of service and advice that exists in the group for the maintenance and repair of vehicles.

4.-Investigating the operation of the vehicles to learn the particularities and difficulties faced by the people in the group to suggest upgrades and/or adaptations.

5.-Integrating the pedagogical methodology of project-based learning in the development of the Specialization Course in Hybrid and Electric Vehicles of Transportation and Maintenance branch at Canastell Vocational Training School.

6.-Encouraging students' awareness towards the group of people with reduced mobility.

7.-Database of technical personnel with specific training.

8.-Disseminating and allowing access to the results and conclusions of sustainable mobility projects to other educational centers or agents, especially highlighting the different working methods, resources, tools or innovative project methodologies used, through materials and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

publications in digital environments, so that they can be educationally useful or improve the educational practices of other teachers or educational institutions.

3. Collaborators and reference institutions

The visits to the **Institute of Electrochemistry of the University of Alicante** and the **National Hydrogen Centre** will provide a vision of the most advanced technological development lines to determine in the design phase, the best options for currently most affordable technologies. Furthermore, in the development phase and the subsequent evaluation of the results, they will be consulted to involve them in the development and results of the tests and obtain the most rigorous and accurate advice possible that facilitates or generates future lines of research that may be useful for both.

4. Gallery and links

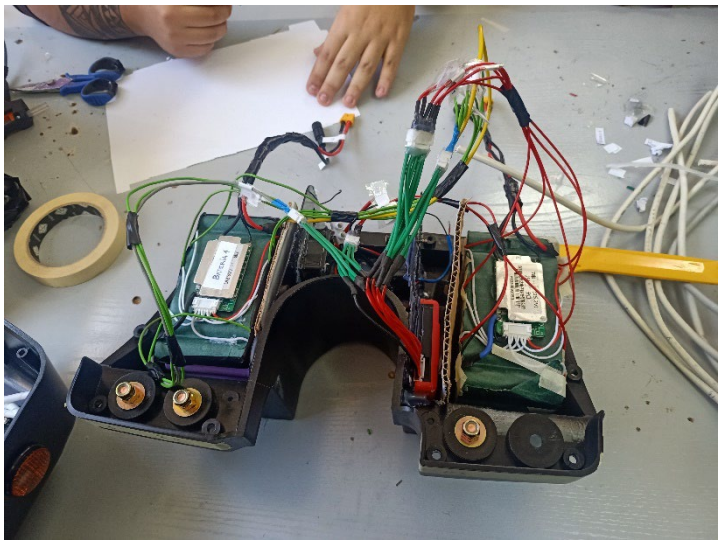
fig.1. First bodywork car prototype developed



Source: Vocational Training School (2023)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig.2 Li-ion Battery prototype v.1.0



Source: Vocational Training School (2023)

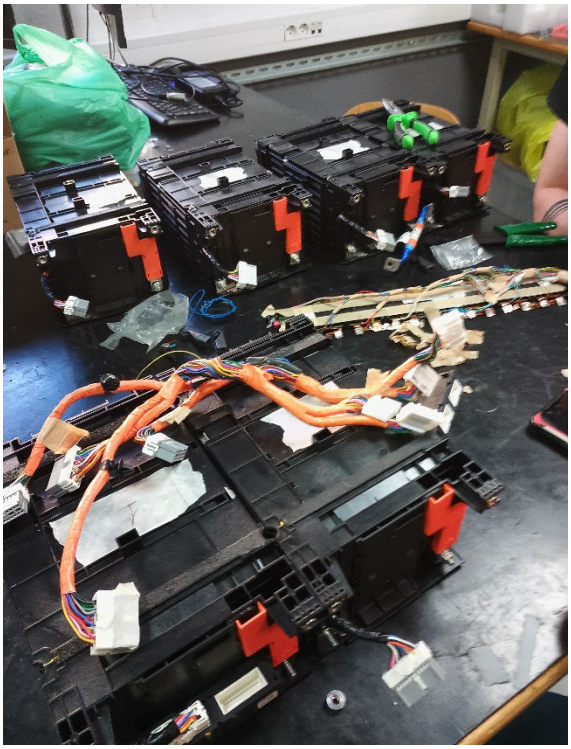
Fig.3. Practices in Fablab and Electric classroom



Source: Vocational Training School (2023)

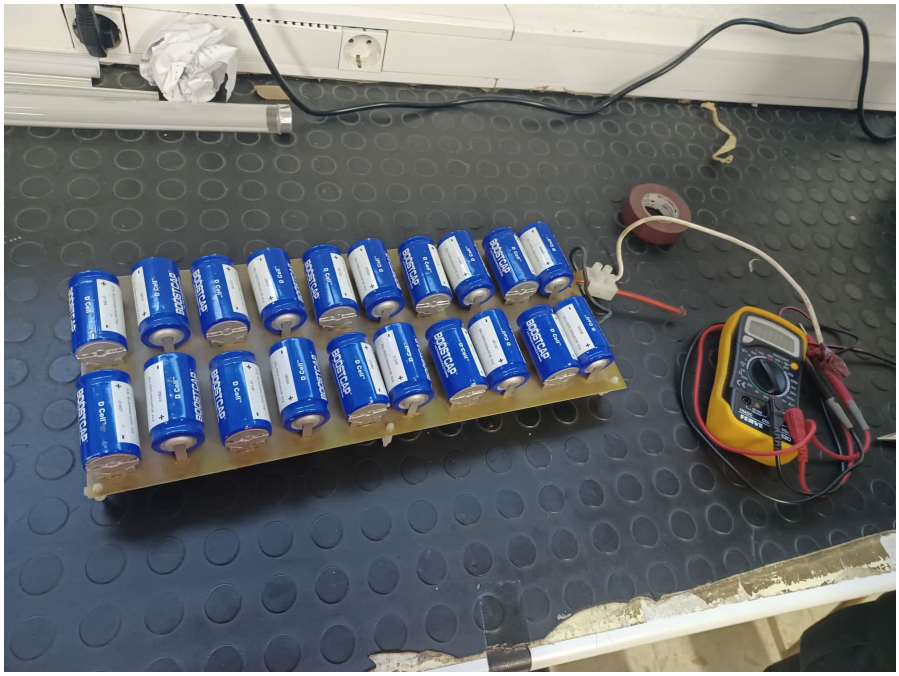
2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig.4. Electric Batery HV v.1.0



Source: Vocational Training School (2023)

Fig.5. Supercapacitors Batery 60V



Source: Vocational Training School (2023)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

AMFI Asociación para mejorar la calidad de vida de las personas con discapacidad física y sensorial a través de su integración social y laboral (https://www.amfi.es/)

CIPFP CANASTELL (https://portal.edu.gva.es/cipfpcanastell/)

INSTITUTO DE ELECTROQUÍMICA DE LA UNIVERSIDAD DE ALICANTE (https://iue.ua.es/)

CENTRO NACIONAL DEL HIDRÓGENO (https://www.cnh2.es/)

2024, Editorial Universitat Politècnica de València BY-NC-SA

Discoveries from a Skills Evaluation on Sustainable Energy in Western Macedonia, Greece

Stefanos Gerardis[a], Athina Krestou[a], Stergios Maropoulos[a], Alkiviadis Tsamis[a], Adam Stimoniaris[b], Sofia Papanikolaou[a], Nikolaos Ntavos[c], Sofia-natalia Boemi[c], Stefanos Dodouras[c], Evridiki Mandela[c]

[a]Department of Mechanical Engineering, University of Western Macedonia, Greece
[b]Department of Chemical Engineering, University of Western Macedonia, Greece
[c]Cluster of Bioeconomy and Environment of Western Macedonia (Clube), Greece

Abstract

This study examines the skill sets related to sustainable energy in Western Macedonia, Greece. It highlights the current state of these skills and their implications for the region's energy transition. The work also highlights the significant role of generic skills in this context. The results provide guidance for educators, industry stakeholders, and policymakers, serving as a foundation for focused activities and strategic planning aimed at improving the development of skills related to sustainable energy. Lastly, the necessity of teamwork, strategic planning, and a strong organizational structure is emphasized, along with the significance of efficient training in addressing the demands of a changing energy landscape.

Keywords: skill analysis; sustainable energy transition; Vocational Education and Training .

How to cite: Gerardis,S.; Krestou, A.; Maropoulos,S.; Tsamis, A.; Stimoniaris, A.; Papanikolaou,S.; Ntavos, N.; Boemi, S.N.; Dodouras,S. and Mandela, E. (2024) Discoveries from a Skills Evaluation on Sustainable Energy in Western Macedonia, Greece. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 297-306. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The region of West Macedonia (WM), that has long served as the "energy heart" of Greece, is currently in the midst of a de-carbonization phase and a transition to a new production model that is independent of fossil -fuels. This transition poses significant advantages and opportunities for development, but it also creates challenges such as high unemployment rates and low competitiveness and innovation rates (Sotiropoulou and Grollius, 2023, Boulogiorgou et al,2022).

The difficulty in finding sufficient employment opportunities is a primary factor contributing to the desertification of the region (Tranoulidis et al, 2022). The dramatic transformations already occurring in the energy sector have led to a notable emigration among the local population, and the anticipated future changes are expected to escalate this trend, potentially leading to a brain drain in the WM area (Farmaki et al, 2021). Although the Region of WM follows the priorities of Europe in its transition to the new production model, there is still room for improvement (Tsioptsias et al, 2019).

Energy transition can pose significant employment opportunities which can only be fully realized if there is a sufficient workforce to carry it out. The involvement of various stakeholders (policy makers, companies, education / training providers) in planned energy installations could be also a solution to mitigate the challenges mentioned previously. Considering the above, the current study conducted in the region of WM, Greece, sought to perform an extensive assessment of the skills available in the area. This thorough analysis explored different facets and levels of skills in the WM region, focusing on energy skills at EQF levels 5 and higher, as well as skills deemed essential by local companies. The study also took into account skills that companies identified as being inadequately mastered. Additionally, an evaluation of the soft skills prevalent in the region was included in the investigation. This information was further used for the development of the WM Regional Plan.The study was conducted as part of the obligations of the SEED project (Erasmus+).

2. An overview of the skills scan study conducted in Western Macedonia, Greece

Focusing on EQF levels 5-8 qualifications, the aim of the study was to assess both the technical and generic skills offered by Vocational Education and Training (VET) providers and universities in the WM region of Greece. Furthermore, some underlying deficiencies that could have an impact on the trained workforce may become apparent by comparing the skills taught in those courses with the abilities required by the labor market.

To find the courses that are relevant to sustainable energy, a comprehensive search for course availability was first carried out.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 shows that of the eight courses that were chosen for review, two Master's Degrees in Sustainable Energy are offered by the University of Western Macedonia (UoWM), while the other courses are offered by VET Institutes, including the UoWM Life Long Learning Center (LLLC of UoWM). Notable features of the University's Master's degree program include its flexible curriculum, which can be readily modified each year to reflect changes in the market. The curriculum is created by relevant academic members.

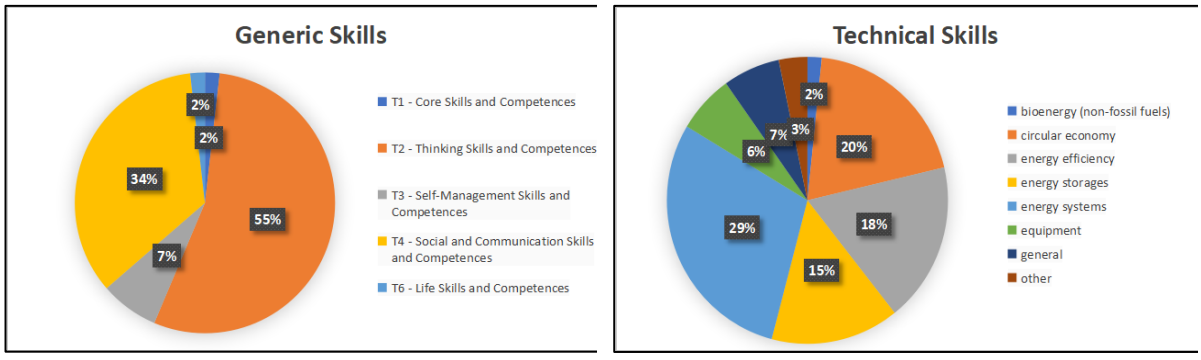
The remaining VET courses fall into two primary categories: public VETs, which follow a curriculum supplied by the Ministry of Education and Religious Affairs, and private VETs, which are created in response to market demands. Public VET providers and UoWM professors have been working closely together in recent years to design customized courses that meet the particular needs of the regional market resulting from the Just Transition phase. The curriculum for every course was carefully reviewed in order to extract the technical skills that were learned as well as the generic skills that were also extracted by modifying the course's scope. The results are shown n Figure 1.

Table 1: List of reviewed courses

Course Title	Offered by
Hydrogen Science and Technology (M.Sc.)	University of WM
Renewable Energy Sources & Energy Management in Buildings (M.Sc.)	University of WM
Modern Energy Storage Technologies and Applications	VET Institute
Energy efficiency and sustainability in small and medium-sized enterprises (SMEs) for energy managers and energy experts	VET Institute
Smart Building Programming Technician	VET Institute
Circular Economy	VET Institute
Reskilling of car mechanics in electromobility	VET Institute / LLLC of UoWM
Technician of Renewable Energy Sources Installations	VET Institute

Source: Own elaboration

Fig. 1 – a) Generic and b) technical skills provided in WM region (categorization according to the ESCO classification)



(a) (b)

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 1a indicates that 55% of the generic skills in the WM region pertain to "Thinking skills and competences" (categorized as T2 in the ESCO classification), with a substantial 34% attributed to "Social and Communication skills and competences" (classified as T4 in the ESCO framework). In terms of technical skills (figure 1b), 62% are associated with energy (including energy systems, energy efficiency, and energy storage), while 20% are linked to the circular economy.

2.1 Insights Gained through Examination of Current Educational Methods and Training Approaches

It became clear from the teaching and training analysis that the labor market does not directly influence curriculum development, particularly for the courses that VET Institutes offer because the majority of them have already been established by the Ministry of Education and Religious Affairs or through partnerships between VETs and the UoWM. Due to the curriculum's rigidity, these courses might not adequately address most local and regional demands; instead, they are geared more toward national requirements. It follows that the presence of skill gaps is expected. Additionally, there may not be enough variety in the skills offered, particularly in technical abilities, given that numerous VET providers offer the same course.

3. Evaluating Skill Requirements: A Comprehensive Skills Needs Analysis

The skills required by the local market were also investigated. Twenty regional businesses, all with varied sizes and specializations in sustainable energy, were questioned after submitting a questionnaire developed for the program's needs. Some of the examined companies are directly linked with the need of suistanable energy specializations need while others not seem inherently linked to sustainable energy at first glance. Such an example are the car repair shops which they play a crucial role in supporting sustainable transportation through various specialized services and practices, such as Electric Vehicle (EV) Maintenance and Repair, alternative fuel vechicles, energy efficiency upgrades etc. In the aforementioned number, companies falling in the same category were merged and included as one business (i.e. more than one car repair workshops replies were merged under the broader category of "automobility"). It was discovered during the assessment of the skills that employers require that new graduates typically have little to no prior work experience. Rather than being immediately put to use after graduation, the most crucial technical skills are frequently learned on the job. Nonetheless, a lot of business reps focused more on the deficiency of soft skills than technical ones, like teamwork and communication abilities. Not to mention, in certain instances, ecological and digital illiteracy was also brought to light. This suggests that rather than offering a more thorough education, current courses may focus too narrowly on particular topics within these fields.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3.1 Critical Generic Skills: Identifying the Pinnacle of Essential Abilities

Cooperation, negotiation, the spirit of teamwork, and the capability to collaborate in groups were identified as highly significant abilities by 46% of the enterprises. The same category also encompasses communication skills, which were underscored as indispensable by 33% of the organizations. Social and communication skills and competencies are foundational proficiencies that empower individuals to effectively disseminate information, ideas, and emotions to others. As per the respondents, proficient communication within a collaborative framework guarantees that team members can exchange ideas, strive towards shared objectives, and efficiently resolve conflicts. Consequently, companies prioritized the acquisition of these skills so they will be better equipped to navigate interpersonal relationships and achieve triumph.

The corporations placed a strong emphasis on the value of cognitive abilities and mental processes, or the critical thinking abilities and competences that people need to analyze information, make decisions, and work through challenging situations.On the other hand, analytical thinking entails breaking down complex problems into manageable parts, examining patterns, and drawing logical conclusions. This particular skill necessitates a systematic and critical approach to information, making it indispensable for decision-making and problem-solving. 40% of the participating companies regarded problem-solving ability and analytical thinking as crucial. Furthermore, organizational abilities were listed as a top priority for prospective employees by 26% of the firms. The participants assert that the ability to successfully manage information and prioritize tasks is crucial for individuals to effectively manage their time and traverse the complexities of complex tasks.

Although the previously mentioned generic skills hold significant importance, companies in the WM region report that these skills are not adequately mastered. Figure 2a provides a graphical illustration of the generic skills that, according to companies, are lacking proficiency.

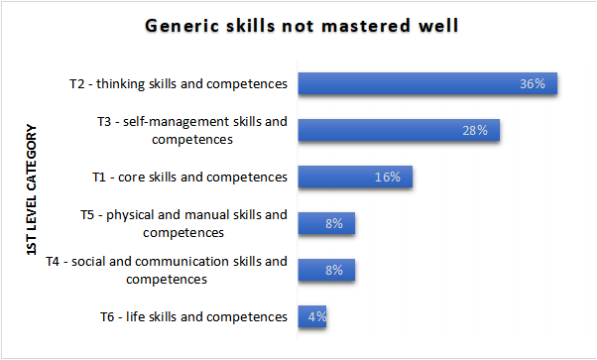
Figure 2a reveals that most underdeveloped skills in the WM region, over 60%, are in Thinking (T2) and Self-Management (T3) categories, with Core (T1), Physical and Manual (T5), Social and Communication (T4), and Life Skills (T6) following in importance.

Specifically, in the T2 category, the corporate survey identifies abilities like initiative and inventiveness as not being adequately learned through the offered VET training. The poll results also emphasize these skills as some of the most important generic skills. In T3, companies note deficiencies in professionalism, efficiency, positivity, and learning new skills.

Interestingly, the skills scan study revealed that 55% of the generic abilities provided by VET courses in the region are in the T2 category, even though most organizations reported lacking expertise in this area.

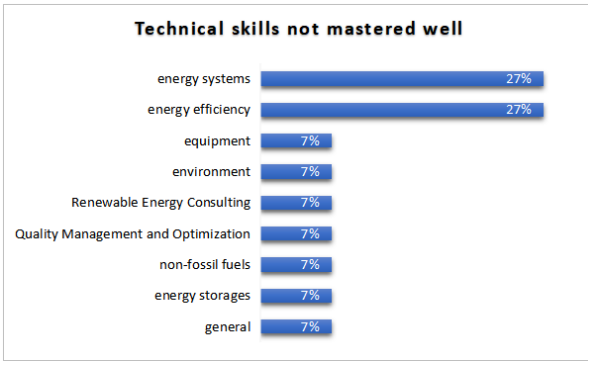
BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 – a) Generic and b) technical skills not mastered well (categorization according to the ESCO classification)



a

Source: Own elaboration



b

Source: Own elaboration

This discrepancy can be ascribed to differences in the demands placed on employees and specific company requirements, as well as a deficiency in feedback, collaboration, communication, and participatory curriculum planning. Furthermore, it should be noted that the majority of trainees leave the area because there aren't enough job possibilities, which results in a loss of skilled workers. This result calls for additional research.

3.2 Critical Technical Skills: Finding the Ultimate Core Capabilities

Regarding technical skills, 28% of the companies cited the necessity of creating new technologies utilizing renewable energy sources (RES), creating energy-saving energy systems within a company's facilities, and having the capacity to plan and implement renewable energy projects. Furthermore, 20% stated that in addition to battery knowledge and skills, energy-saving expertise was necessary for the development of PV installations. Three organizations also mentioned having expertise and skills in engineering and electrical. These talents include, but are not limited to, mechanical engineering abilities such as engineer's calculations and skills related to electrical safety procedures and installations of renewable energy sources.

Companies also provided information on the technical skills they believe are not mastered well. The results are shown in Figure 2b. According to this figure, more than half of the skills that are not well-mastered are related to "Energy Systems" and "Energy Efficiency" (27 percent each), while the remaining 46% are split evenly between other skills like "General knowledge", "Non-Fossil Fuels", "Equipment", "Environment", "Renewable Energy Consulting", "Quality Management and Optimization" and "Energy Storage".

The companies deemed these abilities significant as well, and they correspond with the current state of affairs in Greece's Western Macedonia Region as it enters a Just Transition

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

era. It is interesting to notice that, the majority of curricula available in the area are also focused on developing these skills (Figure 1). However, the majority of these programs—like Master's Degrees—are very new, and there is a limited number of highly qualified people in the area. Moreover, the workforce acquiring generic and technical skills from training/education programs in the WM region tends to seek employment in other regions due to the scarcity of available jobs locally.

3.3 Anticipated future skills needs

Based on their aspirations to diversify into other sustainable energy domains as well as the skills they expected to require in the future from the "Just Transition", the survey respondents highlighted a number of skill trends. More particular, over 93% of participants are willing to proceed with the energy modernization of the company's facilities, the supply and installation of photovoltaic stations, the development of photovoltaic parks for offsetting the enterprise's electricity consumption and to invest in hydrogen storage systems and development of combined heat and power projects alongside with vehicle electrification.

A list of expected talents for the fields described above as well as those that will thrive throughout just transition may be found in the following Table 2. These skills are also aligned with the findings from the World Energy Employment report (IEA, 2023).

Table 2: List of anticipated skills per sustainable energy field

Field	Anticipated Skills
Solar Energy	Supply and installation of photovoltaic stations Development of photovoltaic parks for energy offsetting of electricity consumption of the enterprise
Hydrogen & Fuel Cells	Investment in H2 storage systems Specialists in hydrogen technologies
Electromobility	Vehicle Electrification Knowledge concerning electromobility
Energy Systems	Energy modernization of the company's facilities Energy inspection Energy autonomy
Systems Automation	Development of information systems PLC developer Automation knowledge
Emissions & Environmental Management	Measurement of carbon dioxide emissions Specialists in materials technology

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Training needs analysis

4.1 Gaps in skills and other development priorities

It was noted that among the skills gaps identified by the previously mentioned study, generic abilities are valued more than technical skills. More precisely, soft skills like administrative aptitude, learning flexibility, persuasion abilities, etc. are referred to as "generic skills." For instance, multidisciplinary knowledge or math abilities were required of present employees in addition to web design, marketing, and logistics knowledge; however, those skills were not developed during the courses that were offered and are listed in Table 1. Furthermore, it was noted that certain businesses requested technological expertise, which is now offered by a number of recently launched courses that do not yet have any postgraduate students enrolled. Consequently, these skills were also excluded from the Skills Gaps list, which evolved to include the following areas: Administrative skills, Capacity for "corporate empathy," Control, Learning skills, Logistics, Manual skills, Mathematics, Multidisciplinary knowledge interface, Persuasion, Programming, Sales, Topographical skills, Trends identification, Web marketing and Website design knowledge.

4.2 Overview of regional technical skills training needs

The research indicates that training in the WM region should target key areas. Upskilling teachers in Digital Literacy and Technology Integration is essential for effective use of digital tools in education. Electromobility training is critical due to the move towards eco-friendly transport, covering battery management, charging infrastructure, and electric vehicle technology. With the shift to Renewable Energy, skills in designing, installing, and maintaining renewable systems, and grid integration are necessary. Training in Hydrogen technology's applications in manufacturing, energy, and transportation, including production, storage, and transport, is also vital. Technical expertise in fields like engineering, mechanics, and automation requires continuous updates to match evolving methods and technologies. Environmental Sustainability training is also crucial, spanning conservation, sustainable business, environmental laws, and circular economy, aligning with stakeholder demand analysis.

5. Conclusions

West Macedonia, Greece, is currently transitioning towards sustainable practices. A skill mapping in the region, focusing on the energy sector, revealed that despite the availability of relevant training, expertise in areas like energy storage, systems, equipment, and renewable energy sources (RES) is not sufficiently developed. This issue is partly attributed to the recent inception of these programs, resulting in a shortage of experienced professionals. Moreover, those who acquire these technical skills in West Macedonia often seek employment in other regions, driven by the scarcity of local opportunities.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Companies in West Macedonia, Greece, emphasized also the equal, if not greater, importance of generic skills alongside technical knowledge. Abilities such as critical thinking, self-management, and teamwork are increasingly vital across various industries and roles. These generic skills, which enhance work environments, teamwork, and overall job performance, are highly valued by employers in the region. The skill study suggests that investing in developing these generic skills can open up career advancement opportunities and contribute to personal and professional growth.

Aligning educational curricula with market demands is essential for West Macedonia's transition to a post-lignite period. Informed by this study, a regional strategy is underway to enhance cooperation between businesses and educational institutions. This strategy aims to develop curricula that not only cater to current local job market needs but also anticipate future training requirements. Furthermore, the initiation of a Center of Vocational Excellence (CoVE) is in progress, with a focus on building a strong organizational structure, crucial for the success of this early-stage initiative.

Acknowledgements

The research presented in this paper forms a part of the commitments associated with the SEED project, which has been funded by the European Union's EACEA.A - Erasmus+, EU Solidarity Corps under the Grant Agreement No 101056147..

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Apostolos, Tranoulidis., Rafaella-Eleni, P., Sotiropoulou., Kostas, Bithas., Efthimios, Tagaris. (2022). Decarbonization and Transition to the Post-Lignite Era: Analysis for a Sustainable Transition in the Region of Western Macedonia. Sustainability, doi: 10.3390/su141610173

D. Boulogiorgou ., E.Kondili ,A. Triantafyllou , J.Kaldellis ,(2022), Energy transition in west macedonia. What is the public attitude of the local society?, CEST2021, Proceedings ISBN: 978-618-86292-1-9, Proceedings ISSN: 2944-9820. doi: 10.30955/gnc2021.00800

International Energy Agency, World Energy Employment 2023,(www.iea.org)

Polytimi, Farmaki., Apostolos, Tranoulidis., Thanos, Kouletsos., Paraskevi, Giourka., Androniki, Katarachia. (2021). Mining Transition and Hydropower Energy in Greece—Sustainable Governance of Water Resources Management in a Post-Lignite Era: The Case of Western Macedonia, Greece. Water, doi: 10.3390/W13141878

Rafaella-Eleni, P., Sotiropoulou., Horst-Walter, Grollius, (2023), Decarbonization and sustainable energy transition to the post-lignite era in Greece. doi: 10.5194/egusphere-egu23-4117

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Tsioptsias C., Samiotis G., Kaklidis N., Pekridis G., Amanatidou E.,(2019), Greenhouse Gas Emissions from Natural and Artificial Lakes in Western Macedonia, Greece, CEST2019, Proceedings ISBN: 978-618-86292-0-2, Proceedings ISSN: 2944-9820. doi: 10.30955/gnc2019.00769

2024, Editorial Universitat Politècnica de València BY-NC-SA

Upskilling Heating, Ventilation, Air Conditioning And Refrigeration (HVAC) Technicians On Heat Pump Technologies For Green Energy Transition

Elisa Peñalvo-López[a], Vicente León-Martínez[a], Mar Cañada Soriano[b] and Iván Valencia Salazar[a]

[a]Department of Electrical Engineering, Universitat Politècnica de València, Spain
[b]Department of Applied Thermodynamics, Universitat Politècnica de València, Spain

Abstract

The green energy transition needs a shift towards cleaner and more sustainable forms of heating and cooling. Heat pumps, which extract heat from the environment using electricity, present a crucial component in this transition. However, widespread adoption requires a skilled workforce capable of installing, maintaining, and servicing these complex systems. This is where upskilling Heating, Ventilation, Air Conditioning and Refrigeration (HVAC) technicians on heat pump technologies becomes critical. Investing in upskilling HVAC technicians on heat pump technologies is a valuable step towards achieving a greener future. By addressing the challenges and implementing effective strategies, we can equip the workforce with the knowledge and skills necessary to drive the widespread adoption of these sustainable systems. This, in turn, will contribute to cleaner air, reduced carbon emissions, and a more sustainable energy future. This article presents the Erasmus project PUMP-UP, which contributes to lifting a significant barrier towards the transition of EU heating and cooling to sustainable solutions, namely the lack HVAC technicians heat pump installation skills. The awareness to be raised by the project paired with the increased availability of training opportunities, are anticipated to contribute to the improvement of "green" skills for the HVAC sector.

Keywords: HVAC, sustainability, technicians, skills, cooperative learning

How to cite: Peñalvo-López, E; León-Martínez, V; Cañada Soriano, M and Valencia Salazar, I (2024) Upskilling Heating, Ventilation, Air Conditioning And Refrigeration (HVAC) Technicians On Heat Pump Technologies For Green Energy Transition. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 307-314. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Heating and cooling, still heavily relying on fossil fuels, accounts for about half of the EU energy consumption. Various EU initiatives, such as the EU Strategy on Heating and Cooling (COM/2016/051) and the recent REPowerEU Plan highlight heat pumps as a key solution for reducing GHG emissions from heating and cooling. REPowerEU Plan, launched in May 2022 by the Commission, prescribes that "the European Union should aim at doubling the current deployment rate of individual heat pumps". REPowerEU forecasts indicate that approximately 20M heat pumps will be installed in the EU by 2026 and 60M by 2030; accordingly, on a global level, the number of heat pumps installed is expected to increase from 180 M in 2020 to approximately 600 M in 2030 (European Commission, 2022).

Heat pumps systems are crucial in energy transition in buildings and industries as they play a significant role in minimizing the energy demand of heating and cooling needs (Peñalvo-López, 2023). However, the growth of the heat pump industry is not supported by an equally stable growth in available skilled labour. There is a documented need to equip existing and future heating, ventilation, air conditioning and refrigeration (HVAC) technicians with new and improved competences and skills pertaining to the installation and maintenance of heat pumps. The occupational group of HVAC technicians is listed among the "most often reported shortage occupations" by the European Labour Authority (ELA), with 9 countries reporting shortages in 2020. On top of this shortage of "conventional' HVAC technicians, there is an even greater scarcity in technicians who are qualified to work with the latest heat pump technologies.

The lack of qualified technicians is often identified as one of the key bottlenecks hindering the wider uptake and roll-out of heat pump solutions. Delivering on the "REPowerEU" target for heat pump installations requires immediate action towards the upskilling of the HVAC sector.

2. PUMP-UP project

PUMP-UP aims to improve the supply, quality, and relevance of Vocational Education and Training (VET) for HVAC technicians to address the occupational skills needs and mismatches. The project builds on current skills intelligence to develop a learning outcome-oriented VET curriculum with Work-Based Learning (WBL) components on heat pump installation and maintenance, providing HVAC technicians and trainees with upskilling pathways, to keep up with labour market sustainability targets and trends. The main objectives of the project are:

- OBJ1: Revise occupational requirements for HVAC technicians to match the demand for green heating & cooling.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- OBJ2: Develop a novel curriculum for dual vocational training on heat pump technologies. OBJ3: Introduce open-access delivery methods to increase VET flexibility and inclusiveness. OBJ4: Foster heat pump skills recognition via a micro credential-based certification scheme.
- OBJ5: Foster the capitalisation of project results in VET practice via integration in HVAC qualification outlines.

In order to respond to these objectives, PUMP-Up has defined a series of activities that are planned to be implemented in 2024 to 2026. These activities include:

- Consultation with experts on learning outcomes formulation.
- Joint design of a VET curriculum & Open Educational Resources (OERs) on heat pump technologies.
- Development of wide-access delivery methods for the PUMP-UP curriculum.
- Pilot delivery and evaluation of curriculum's learning effectiveness.
- Sectoral recognition of HP occupational requirements.
- Development of a Blueprint for the update of HVAC occupational profiles & qualifications.
- Inclusion of heat pump skills requirements into ESCO & national classification systems.

Based on the programme activities, it is expected to reach the following results to respond to the needs of the HVAC sector:

- A modular curriculum with WBL components on heat pump technologies in 7 languages (EQF4, 140 hours duration).
- A MOOC and a "virtual assistant" application.
- A certification scheme for heat pump skills based on micro-credentials.
- Blueprint for an EU-wide qualification for HVAC technicians, and updated profile on ESCO.
- 7 on-site training seminars & 8 online Training the Trainer (TTT) sessions.
- 1000 HVAC technicians trained and upskilled.
- 7 national info-days and an EU Conference on HVAC trends and reskilling needs.

3. Target Groups

The fast-paced expansion of heat pumps in residential buildings and industry (37% EU market growth in 2022) paired with EU projections to accelerate the deployment rate for increasing energy security is rapidly pushing up the demand for qualified technicians. Nonetheless, the HVAC sector is severely strained by skills shortages. Based on current growth estimates (IEE,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2022), the EU will need at least 110,000 heat pump installers to deliver on its deployment target (60 million heat pumps by 2030); still only 1 in 4 HVAC technicians is currently qualified to work on heat pump technologies. This highlights the urgent need to update existing curricula and bridge the widening skills gap via both upgraded I-VET and re-skilling opportunities.

In this context, the PUMP-UP partnership investigated the labour market to define skills requirements & mismatches in the consortium countries (and beyond) and define the project's intervention logic reflecting on target groups' needs. Results of this analysis noted the importance of focusing on five main target groups: Learners, VET Training providers, Industry actors and Social organisations. For each of the target groups was identified the problems faced and the needs addressed by PUMP-UP.

A) LEARNERS: Consist on HVAC technicians and formal & informal trainees and apprentices. Based on European Labour Authority report, there are approximately 158,000 HVAC technicians in Europe, and the problems they faced include:

- Lack of technical and non-technical heat pump installation skills which are increasingly in demand within the industry.
- Limited access to (flexible) continuous training opportunities, to keep up with sectoral trends & emerging workplace requirements.

Identified Needs:

- Keep up with current market trends/demands (PR).
- Have access to formal & flexible VET and C-VET training opportunities (PR).
- Achieve recognition of their skills as acquired through non-formal learning (PR).
- Improve their intra-EU mobility through common qualification requirements (SE).

B) VET TRAINING PROVIDERS: represent the VET providers offering HVAC training programs. According to the European Association of Institutes for Vocational Training (EVBB), it is estimated a population of 1,500 VET providers in the European Unios. Key problems faced by this group include:

- Lack of educational resources on the installation of modern heat pump systems.
- Non standardized educational requirements for HVAC technicians.
- Low responsiveness to new market trends.
- Low attractiveness of HVAC training programs.

Identified Needs:

- Match their training offerings to sector demands (PR).
- Gain access to easily deployable educational resources on heat pump installation (PR).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

C) INDUSTRY ACTORS: this group includes HVAC installation companies & Heat pump manufacturing companies, which involve more than 5,500 HVAC installation companies and 500 heat pump manufacturing companies active in the EU.

Main challenges faced by the industry include:

- Difficulty in recruiting qualified HVAC installers.
- Lack of in-house training capacities and resources.
- Lack of qualified installers hindering installation rates (sales).

Identified Needs:

- Improve organizational learning and increased quality of in-house training provision (PR).
- Increase availability of qualified HVAC technicians (PR).
- Increase heat pump installation rates (SIDE).

D) SOCIAL PARTNERS: involve European and National HVAC associations and professional unions, environmental organisations, accreditation/qualification bodies Key problems faced:

- Low attractiveness of the HVAC sector as a career choice.
- Ageing workforce and low replenishment rates.
- Low responsiveness of VET training to sectoral trends.
- Lack of common qualification/certification requirements for HVAC technicians.

Identified Needs:

- Establish common occupational/educational requirements for HVAC technicians, improving intra-EU mobility (PR).
- Lift the mismatch between HVAC VET training activities and market realities (PR).
- Improve the attractiveness the HVAC sector as a career choice (SE).
- Increase sectoral growth & support the greening of heating & cooling (SIDE).

To address the above needs of the different target groups, PUMP-UP plans to:

- Design a modular VET curriculum on heat pump technologies, based on up-to-date skills intelligence and linked to EU recognition tools.
- Create an online course and a Virtual Assistant application to provide open, flexible reskilling opportunities.
- Provide upskilling opportunities to >900 HVAC technicians/trainees and >70 VET trainers.
- Set EU-wide occupational requirements and update existing HVAC profiles & qualifications.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Set up an online examination scheme based on micro-credentials to validate heat pump skills acquisition.
- Set forward a communication strategy for the uptake of project results, aiming at the integration of PUMP-UP resources in VET training offerings as well as increasing the attractiveness of the HVAC sector as a career choice.

4. Expected Impact

An evidence-based procedure is employed to measure the effectiveness of the project in accomplishing its strategic/operational goals, as well as achieving the expected impact on partners and target groups. Overall, impact analysis will be based on project's performance (impact) against the pre-defined Key Performance Indicators (KPIs). Main target KPIs include: a minimum target of 21 stakeholders' involvement in the consultation for the definition of learning outcomes and topics selection, developing specific training material to support a curriculum for 140 hours duration, translate the training material to 7 different languages, and engagement of VET providers, HVAC installation companies and heat pump manufacturers to express their interest to integrate PUMP-UP learning outcomes and materials into their training offerings/activities.

In order to achieve the expected impact, the project involves a European partnership of seven organisations with extensive expertise and specific roles in the project to carry out the activities and achieve the ambitious goals. The collaborative initiative involves:

- UPV brings all the necessary research & education related capacity in engineering studies to ensure effective course design and delivery. It further provides direct access to 30,000 students.
- TARTUVOCO, CELF and RENAC provide an extensive experience in VET and dual training in various energy fields, including HVAC. They can also provide direct access to approximately 5,500, 2,500, and 3,500 students respectively; RENAC also works with the industry to develop educational standards, qualifications & apprenticeships.
- PROMEA has extensive capacity in the development of creative & innovative ICT-based learning methodologies including online courses & simulation games.
- ECQA is expert in developing and administering (EU-wide) certification schemes for competences and skills in numerous occupations.
- INNOVELA has substantial expertise in communication activities and the use social media for marketing purposes as well as the capacity to create cutting-edge training resources (e.g., educational apps).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

5. Conclusions

EU plans to rapidly increase the deployment rate of heat pumps depend on the upskilling and availability of properly trained HVAC technicians. This article presents the project PUMPUP, a European initiative focused on strengthening the adaptation of the workforce to current market needs and support the HVAC sector's growth and innovation. Along the article it is presented the novel educational initiative for upskilling Heating, Ventilation, Air Conditioning and Refrigeration (HVAC) technicians on heat pump technologies based on providing HVAC technicians a freely accessible upskilling path, through flexible training solutions and a micro-credential, ensuring market recognition & cross border mobility.

Acknowledgements

This work has been carried out within the framework of the research project PUMP-UP "Upskilling HVAC technicians on heat pump technologies for green energy transition" funded by the European Commission within the Key Action 2: Cooperation partnerships in vocational education and training, reference number: 2023-1-ES01-KA220-VET-000164956.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

European Commission, (2016). Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. An EU Strategy on Heating and Cooling (COM/2016/051 final). Online access on February 2024. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0051.

European Commission, (2022). Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions. REPowerEU Plan (COM/2022/230 final). Online access on February 2024. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN.

International Energy Agency, (2022). The Future of Heat Pumps. World Energy Outlook Special Report. Online access on February 2024. https://iea.blob.core.windows.net/assets/4713780d-c0ae-4686-8c9b-29e782452695/TheFutureofHeatPumps.pdf

European Labour Authority, (2021), Report on Labour Shortages and Surpluses. Online access on February 2024. https://www.ela.europa.eu/en/media/725.

Ankita Singh Gaur, Desta Z. Fitiwi, John Curtis, (2021). Heat pumps and our low-carbon future: A comprehensive review, Energy Research & Social Science, Volume 71,2021,101764, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101764.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Peñalvo-López, Elisa; León-Martínez, Vicente; Fort Gadea, Vicente José (2023). Enhancing Energy Professional Skills in Nearly Zero Energy Buildings (nZEB). EN 11th International Conference on Innovation, Documentation and Education (INNODOCT 2023). (1 - 11). Bucaramanga, Colombia: Latin America.

Peñalvo-López, Elisa; Molina-Cañamero, Laura; Valencia-Salazar, Iván (2023). Training programme in Decarbonisation audits for intense energy industries. EN 11th International Conference on Innovation, Documentation and Education (INNODOCT 2023). (1 - 12). Bucaramanga, Colombia: Latin America.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Romania On The Path Of Energy Transition - From European Projects To Citizens' Perception

Istrate Marinela[a]

[a] Faculty of Geography and Geology, Department of Geography, Alexandru Ioan Cuza University of Iasi, Romania

Abstract

The European Union's energy policy underlines the importance of green and clean energy in combating global warming and preventing climate change, encouraging cooperation in the areas of renewable energy, in order to increase the security of energy systems and the stability of supply. Romania is ready to assume the role of energy hub and stability provider in South-Eastern Europe, having all the necessary resources, from solar and wind power to nuclear power and geothermal sources (Koltsaklis et al. 2020; Filis and Leal-Arcas, 2023; Spiru, 2023). This article aims to provide recent perspectives on the use of renewable energies in Romania and to evaluate the impact of European funds on Romania's performance in terms of increasing the share of renewable sources in energy production, using the data provided by Eurostat and by the Romanian institutions that monitor the energy sector and deal with the implementation of European policies. The article also investigates the perception of Romanian citizens, compared to European ones, towards the efforts made to achieve energy objectives by 2050. Public perception is assessed by taking into account the results of Eurobarometer 527 and 538 achieved in 2022 and 2023. The conclusions show that Romania's performance in terms of increasing the share of renewable energy sources places it among the leaders at the regional level, as installed power and funds attracted in this field, but the level of involvement and concern of Romanian citizens towards the topic of climate change and energy transition is moderate, often below the European average.

Keywords: renewable energy; green transition; public perception; Romania.

How to cite: Marinelaa, I (2024) Romania on the path of energy transition - from European projects to citizens' perception. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 315-323. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction and General Background

The energy sector, both at the European level and in Romania, is in full transition to green, clean energy, namely the decarbonization of energy systems, the reduction of greenhouse gas emissions and the promotion of renewable sources, as well as ensuring the security of supply with electricity at an affordable level of costs for the final consumer. Europe aims to become the first climate-neutral continent by 2050. To this end, the European Green Deal was launched in 2019, an ambitious package of measures to allow a sustainable ecological transition, complemented by Directive (EU) 2023/2413. The EU's energy objective for 2030 was set in 2018 at 32%, with subsequent proposals to reach 42.5% (European Commission, 2021). Extensive and diverse measures are included, from reducing emissions in all economic sectors (energy and transport in particular), to investing in research and innovation to strengthening the circular economy (Filis and Leal-Arcas, 2023). As a member state of the EU, Romania is committed to complying with the essential principles of the European Green Pact, and the analysis of the evolution of the energy sector in recent years shows that the medium-term targets are achievable (Bănică and Istrate, 2015; Spiru, 2023). Several structural challenges affect Romania's prospects for sustainable economic growth and inclusion while hindering the transition to a greener economic model, with a clear need for further structural reforms in the future (Marinescu, 2020; Koltsaklis et al., 2020). Achieving the goal of zero net emissions by 2050 will bring substantial challenges, requiring both political and population interventions (Roberts, 2020; Standal et al, 2023; Wang et al., 2023). Substantial emissions reductions will be needed in sectors that are difficult to change, challenges related to institutional capacity, the ability to absorb funds and the implementation of persistent structural changes will have to be addressed, in order to unlock the opportunities it can offer the green transition (Busch, 2021). This article represents an exploratory assessment of the situation of Romania in terms of the implementation of European energy objectives, on the one hand, and the citizens' perception of these approaches, as it results from investigations at the European level, on the other hand. The article is structured as follows: introduction and general context, the dynamics of the production of green energy in Romania and the main projects carried out with European funds, perception of climate change and green energy transition from the perspective of Romanian citizens compared to European ones. The article ends with a short section of conclusions, which provides some milestones on the prospects of deepening the studied issue.

2. Data and Methods

A synthetic look at the state of implementation of renewable energy was extracted from the comprehensive database available both at the European level (Eurostat) and at the national level, respectively the data provided by the National Institute of Statistics, the National Regulatory Authority in the Field Energy, Transelectrica and the Romanian Ministry of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Energy. The selected indicators are also those of greatest interest for the present study: share of energy from renewable sources, electricity production by categories of power plants, financing programs for renewable energy projects, etc. The degree of citizens' interest in the climate change agenda and the opportunity to transition to green energy can be quantified by analyzing the Eurobarometer results. Thus, we took into account two Eurobarometer (527 and 538), from which we selected only a few questions, considered more relevant (table 1). Graphic processing was limited to a few linear and column graphs made in Excel.

Table 1 - Eurobarometer and selected questions

Eurobarometer	Questions
527: Fairness perceptions of the green transition	
Total EU27 26,395 interviews Romania 1,056 interviews Fieldwork: 30 May - 24 June 2022	**QA1.1.** Do you feel a personal responsibility to act to limit climate change? (%)
	QA5.1. How confident or not are you about these statements regarding the reduction of energy use? Overall, how confident are you personally that you could use less energy than you do now? (%)
	QA4. Thinking about the main reason why you would reduce your energy use, which one corresponds best to your situation? You would reduce your energy use: mainly for economic reasons, mainly for environmental reasons, you would not reduce your energy use.
538: Climate change	
Total EU27 26,358 interviews EU27 RO Outer pie Inner pie Romania 1,065 interviews Fieldwork: 11 May - 29 May 2023	**QC1T.** Which of the following do you consider to be the single most serious problem facing the world as a whole?
	QC2. And how serious a problem do you think climate change is at this moment?
	QC4. To what extent do you agree or disagree with each of the following statements? The costs of the damages due to climate change are much higher than the costs of the investments needed for a green transition
	QC5. Have you personally taken any action to fight climate change over the past six months?
	QC6. Which of the following actions, if any, apply to you? (You try to reduce your waste and you regularly separate it for recycling; When buying a new household appliance, lower energy consumption is an important factor in your choice; You regularly use environmentally-friendly alternatives to your private car such as walking, cycling, taking public transport or car-sharing)

Source:https://europa.eu/eurobarometer/surveys/detail/2672;
https://europa.eu/eurobarometer/surveys/detail/2954

3. Results and Discussions

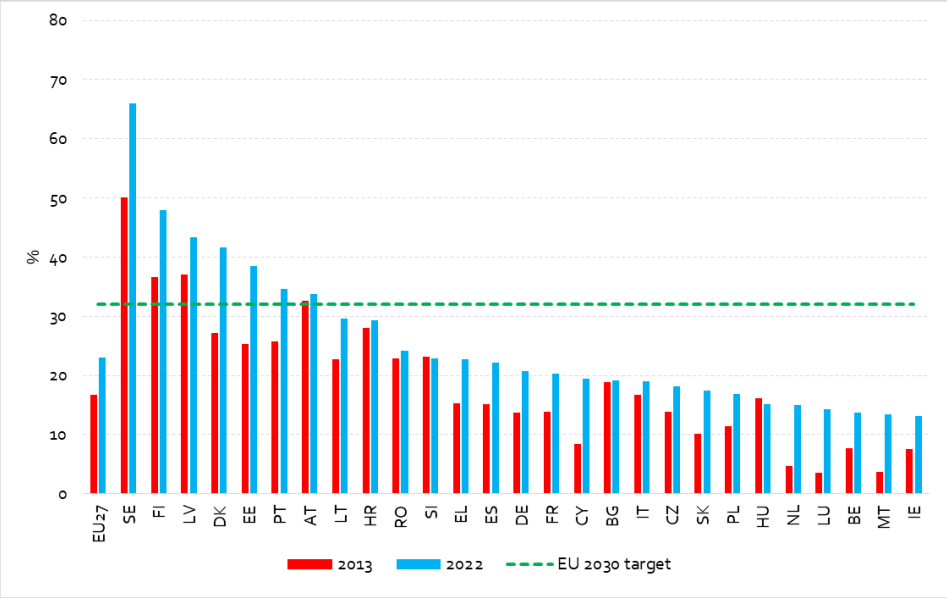
3.1. Towards a sustainable energy system in Romania

The share of renewable sources in energy consumption at the EU level reached 23% in 2022 (figure 1). As the European Union's renewable energy target for 2030 was set at 32%, but the new target looks set to be 42.5%, EU countries must step up their efforts to collectively meet

BY-NC-SA 2024, Editorial Universitat Politècnica de València

the new target, which involves increasing the share of renewable energy sources in gross final consumption. Romania ranked 10th in the EU, with a proportion of 24.14% (from 23% in 2013). In total, 17 of the 27 EU members reported shares below the EU average of 23.0% in 2022.

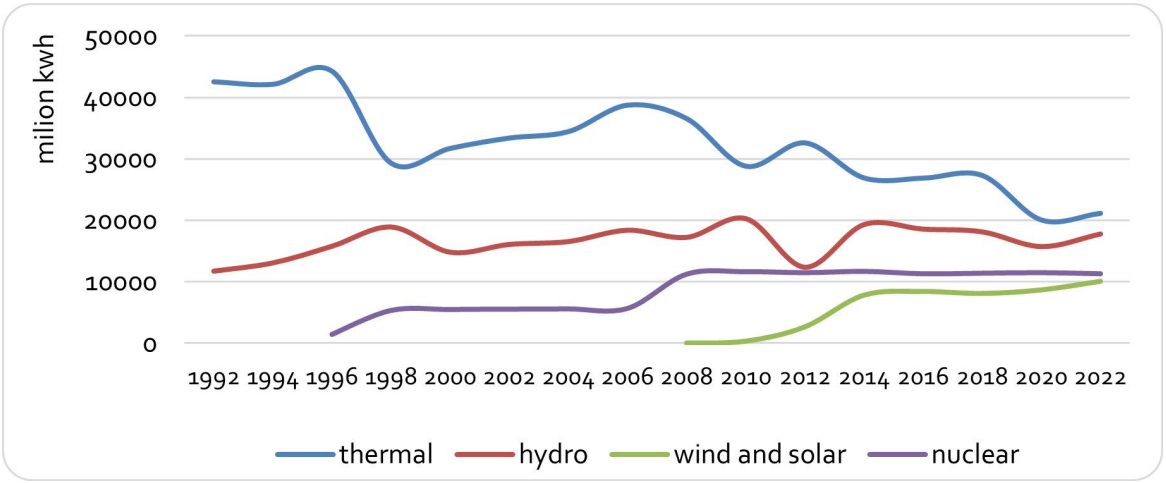
Fig. 1 - Share of energy from renewable sources 2013 and 2022 (%) and 2030 EU target



Source: Eurostat

Romania has proposed ambitious plans related to the share of renewable energy in total energy sources (figure 2). Its energy strategy is based on an energy mix, in which renewable sources and nuclear energy play an important role in reaching the target of zero net emissions by 2050.

Fig. 2 - Electricity production by categories of power plants in Romania

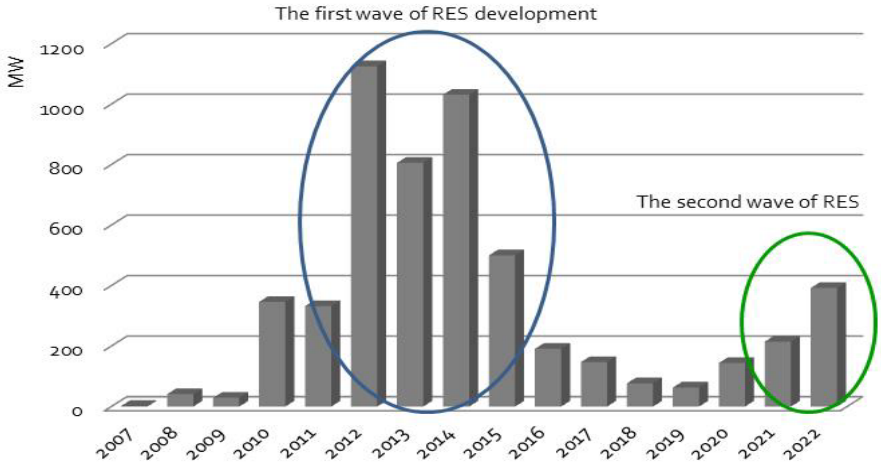


Data source: National Institute of Statistics of Romania

2024, Editorial Universitat Politècnica de València BY-NC-SA

Romania also aims to become a regional leader in energy operations and implementation of nuclear but is also the first country to install wind energy production capacities in the Black Sea. Investments in renewable energy recorded a sudden increase in the interval 2010 – 2014, with almost 40% of the companies active in this market being established in that period (figure 3). In the first wave of renewable energies, 3000 MW in wind capacity and 1400 MW in the photovoltaic sector were installed in Romania. In 2014 alone, 89 renewable energy companies were established, which marked the peak of the first wave of investments in green energy (wind, especially) in Romania.

Fig. 3 - New energy production capacities from renewable sources (MW added annually)



Data source: Transelectrica, 2023

This phenomenon is explained by a legislative amendment that allowed the granting of incentives to the producers of green energy, namely the granting of green certificates for each MWh generated. Electricity suppliers were also required to purchase a certain number of green certificates. This support scheme attracted both domestic and international investors and led to the achievement of the renewable energy object for 2020 a few years ahead of schedule, given that the hydropower sector, already very well developed from the communist period, had given Romania an advance compared to other central-eastern European countries. The granting of green certificates was stopped in 2016 under the pretext that they led to an increase in electricity prices for consumers; once government support was reduced, investments in green energies also slowed down significantly. In the following years, while the European states accelerated the production of green energy, Romania stagnated in this regard and only the European financing for the green transition set things in motion. Currently, we can talk about a second wave of renewable energy in Romania. For example, in 2022, renewable projects with a capacity of about 6,400 MW, the equivalent of about 6 billion euros in investments, obtained approvals or contracts to connect to the grid. The new wave of renewables (solar, wind, biomass, geothermal) covers, unlike the first, not only large

BY-NC-SA 2024, Editorial Universitat Politècnica de València

projects but also smaller consumers, who are looking for a long-term solution to the pressure of bills. Green energy is increasingly becoming the preferred answer for lighting, (micro-)electricity generation and even heating. Thus, the energy market is currently open to domestic customers as well, and programs with public funding (European and national) allow entry into this market including smaller municipalities, which include green energy systems in their development projects. It thus becomes a reality that Romania is in the midst of a boom in the installation of renewable energy capacities.

3.2. Financing programs for renewable energy projects.

The main engine of the growth of renewable energy projects in Romania is currently represented by the significant funds made available by the European Union to support European countries on the way to economies without carbon emissions. Below are some of these projects: i) National Recovery and Resilience Plan (PNNR). Until 2026, Romania can absorb funds worth approximately 1.6 billion euros through Component C6 – Energy from the PNNR financing. Added to this is the new RePowerEU program, launched in 2023, worth 3 billion euros, which aims to finance both new investments in green energy, especially solar energy, as well as the modernization and digitization of the electricity network; ii) Modernisation Fund. In 2023, Romania received 1.1 billion euros for new investments in generating electricity from renewable sources, the modernization of energy networks, and the improvement of energy efficiency. Until 2030, another billion euros will be directed towards increasing the capacity of the transport system and consolidating distribution networks, and the development of solar energy production units; iii) Just Transition Mechanism. It is designed as a scheme to reduce the negative effects of the energy transition and will finance, through the 2.1 billion euros made available to Romania, the actions to gradually eliminate the use of coal in the energy industry until 2032.

3.3. Public perception of green transition and climate change

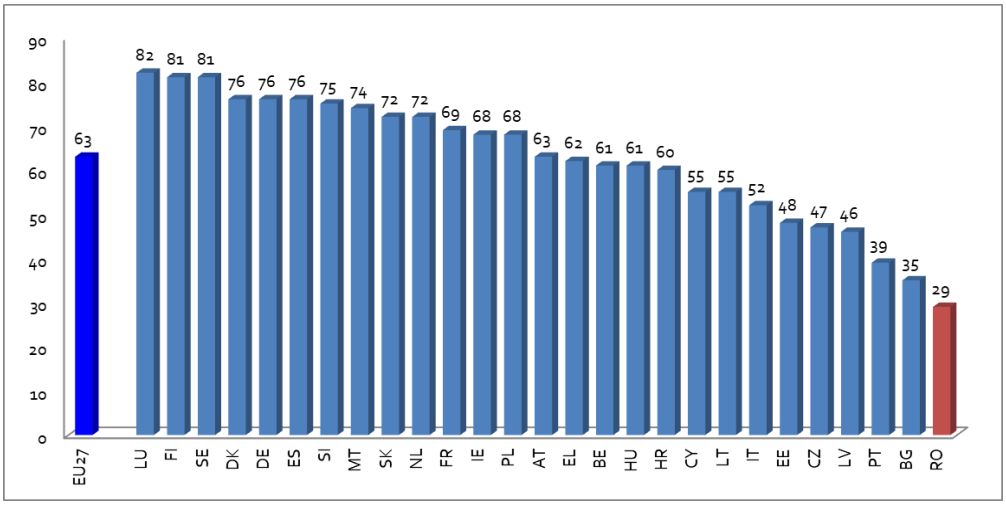
The attitudes and expectations of Romanian citizens towards the green transition and the impact it will have on their lives, the perception of the current energy situation, the desire to reduce energy consumption and the motivation to do so, all were evaluated keeping account of the results of surveys carried out at the European level, respectively Special Eurobarometer 527 (*Fairness perceptions of the green transition*) and Special Eurobarometer 538 (*Climate change*). Following the analysis of the answers, it emerges that, at this moment, in the Romanian public space, the major concerns are related to the economic and health situation, energy and environmental issues not being considered so urgent. Thus, only 63% of Romanians surveyed (as opposed to 77% of Europeans) consider it a personal responsibility to act to limit climate change, and 33% do not agree with this idea at all. 61% do not think that they could consume less energy than at present and only 36% are willing to consider a

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

possible reduction in energy consumption. However, if they had to name the most important reason why they would reduce energy consumption, 66% of the Romanian respondents mentioned the economic reason (compared to 62% European citizens) and less than a third (31%) environmental reasons (compared to the 36% European citizens). Not surprisingly, those over 55 years old mostly chose economic motivation, while those in the 15-24 age group would reduce energy consumption for environmental reasons. Just like other European citizens, Romanians with high and very high incomes are more willing to reduce energy consumption for environmental reasons. According to the answers to Eurobarometer 538 questions (*Climate change*), Romanians consider that the most serious problems facing the world today are armed conflicts (47% of respondents), the economic situation (43%), poverty, and hunger (41%). Climate change, the deterioration of nature, or diseases caused by pollution are considered serious problems by just over 20% of Romanians.

The problem of climate change is considered to be very serious by 77% of European citizens and only 53% of Romanians. At the same time, the percentage of Romanians who do not believe in climate change is almost double the European average (13% versus 7%). As such, the share of those who have acted in any way in the last 6 months for a cleaner world is the smallest compared to the citizens of other European countries. (figure 4).

Fig. 4 - Citizens taking action to fight climate change over the past six months (%)



Data source: Eurobarometer 538

There are also significant differences between the answers of the Romanians and those of the Europeans regarding the cost of climate change versus the costs necessary to implement the green transition. 53% of Romanians believe that the damage caused by climate change can be much greater (compared to 73% of Europeans), but, at the same time, 34% completely disapprove of this statement (compared to only 16% of Europeans). In general, Romanians do not consider it their responsibility to act against climate change, but rather someone else should deal with this problem (regional and local authorities, the national government, the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

European Union, etc.). 58% of EU citizens (and only 36% of Romanians) believe that the use of renewable energy sources should be accelerated, energy efficiency should be increased and the transition to a green economy should be accelerated. From a socio-demographic point of view, Romanian young people (15-34 years old), those with higher education and with above-average incomes declare in a significantly higher percentage that they largely agree with the energy transition and that climate change is real and produces visible effects. Romanians with low incomes, the elderly, and those with primary education agree to a small extent or not at all with the energy transition and do not consider climate change to be real.

4. Conclusions

Without a doubt, political decision-makers in Romania, private companies and organizations active in the fields of energy and climate change have on their agendas, as major concerns, the management of environmental problems, the acceleration of the transition towards a sustainable energy system, as well as the aspects related to the circular economy. Also, climate and environment education is becoming more and more important in the school curriculum in Romania. The vast majority of young people believe that the accumulation of knowledge about climate change in school is essential for their involvement in climate action. Even assuming that these responses reflect desirable behaviors or a tendency towards social conformity, they show a strong awareness of the fact that through personal consumption behavior, people can help protect the environment.

The data show that although there is a fairly high degree of concern among young people for energy transition and climate change, this is not complemented by concrete actions to mitigate the effects and/or combat climate change. Although the 15-34-year-old group declares itself to be the most concerned when it comes to actions taken, it does not differ significantly from the 55+ age group. At the national level, the willingness of citizens to pay for the green transition is extremely low. Especially in the current economic context, Romanian young people, like most of the population, do not perceive themselves as having the financial readiness to pay more for energy or transport costs, they rather resonate with the principle of financial accessibility for all and, in particular, for disadvantaged and poorer households. Romania needs a real implementation of the concept of active citizenship, to educate young people as the real agents of change and not just to consider them as an impersonal group of people to whom public policies are delivered. In addition to involving young people in the decision-making process of public policies on climate change and the transition to a green economy, this study highlights the importance of education on environmental sustainability and climate change. When education is weak and understanding of the green transition is limited, there is a risk that young people will opt for extremist agendas or climate-denial positions. A solid sustainable and green economy can

2024, Editorial Universitat Politècnica de València BY-NC-SA

develop in Romania only through sustained efforts to build the population's trust in the entire mechanism.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bănică, Al., Istrate, M. (2015). Towards A Resilient Energy System In Eastern Romania – From Fossil Fuels To Renewable Sources. *Annals of the University of Oradea*, Geography series, XXV (2), 148-156.

Busch, H., Ruggiero, S., Isakovic, A., Hansen, T. (2021). Policy challenges to community energy in the EU: a systematic review of the scientific literature. *Renewable and Sustainable Energy Reviews*, 151, 111535, https://doi.org/10.1016/j.rser.2021.111535

Renewable Energy Directive revisión (2021). European Commission. https://commission.europa.eu/news/commission-presents-renewable-energy-directive-revision-2021-07-14_en (accessed 10 January 2024)

Filis, A., Leal-Arcas, R. (2023). Energy decentralization and energy transition in Romania. In: Electricity Decentralization in the European Union: Towards Zero Carbon and Energy Transition, Second Edition, 2023, 599-635.

Koltsaklis, N.E., Dagoumas, A.S., Seritan, G., Porumb, R. (2020). Energy transition in the South East Europe: The case of the Romanian power system. *Energy Reports*, 6, 2376–2393, https://doi.org/10.1016/j.egyr.2020.07.032

Marinescu, N. (2020). Changes in Renewable Energy Policy and Their Implications: The Case of Romanian Producers. *Energies*, 13, 6493, doi:10.3390/en13246493

Roberts, J. (2020). Power to the people? Implications of the clean energy package for the role of community ownership in Europe's energy transition. *Review of European, Comparative & International Environmental Law*, 29, https://doi.org/10.1111/reel.12346

Standal, K., Leiren, M.D., Alonso, I., Azevedo, I., Kudrenickis, I., Maleki-Dizaji, P., Laes, E., Di Nucci, M.R., Krug, M. (2023). Can renewable energy communities enable a just energy transition? Exploring alignment between stakeholder motivations and needs and EU policy in Latvia, Norway, Portugal and Spain. *Energy Research & Social Science*, 106, 103326, https://doi.org/10.1016/j.erss.2023.103326.

Transelectrica (2023). Annual Report 2022. Retrieved from: https://www.transelectrica.ro/documents/10179/15188141/Raport+anual+2022_ENG.pdf/06e4f48e-5b56-4d71-94a4-8f6566958be8

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Exploring Local Solutions to Address Energy Access Deficit for Off-grid Communities in Nigeria Through Collaborative Learning

Misbahu Ladan Mohammed[a], Aminu Bayawa Muhammad[a], Abdullahi Muhammad Sokoto[b], Muhammad Saifullahi Ladan[c] and Zaharadden Muhammad Ladan[d]

[a]Department of Energy and Applied Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria
[b]Department of Pure and Environmental Chemistry, Usmanu Danfodiyo University, Sokoto, Nigeria
[c]Bioresources Development Centre Jega, National Biotechnology Research and Development Agency, Nigeria.
[d]Bioresources Development Centre Kano, National Biotechnology Research and Development Agency, Nigeria.

Abstract

Scientific collaboration has been identified as a mutually beneficial process that yields favorable outcomes for many African countries towards achieving a number of United Nations Sustainable Development Goals (UN SDGs). In this respect, Usmanu Danfodiyo University Sokoto (UDUS) Nigeria has joined the Transforming Energy Access-Learning Partnership (TEA-LP) to develop local professionals with the skills and competencies to improve energy access for off-grid communities. In this partnership, TEA-LP is providing technical and financial support for the uptake of two new courses into the UDUS M.Sc. Renewable Energy programme. The energy access courses adapted by UDUS through the TEA-LP collaboration are: (i) Local Solutions for Energy Access, and (ii) Appliances for Off-grid Communities. The added courses aim to address the challenges of energy access and equip students with the necessary skills for sustainable energy practices. This paper will discuss the impact of the partnership to date on the UDUS M.Sc. Renewable Energy programme, the teaching methods being used for delivery of the learning outcome, the modalities employed in adapting the two new TEA-LP courses into the existing curriculum and the impact of TEA-LP on the target communities.

Keywords: energy access; off-grid communities; partnership.

How to cite: Mohammed, M. L.; Muhammad, A. B.; Sokoto, A. M.; Ladan, S. M. and Ladan, Z. M. (2024) Exploring Local Solutions to Address Energy Access Deficit for Off-grid Communities in Nigeria Through Collaborative Learning. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 324-331. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The past few decades have seen a sharp increase in the amount of energy consumed for heating, steam and electricity due to rapid development in the transportation, industrial, agricultural, residential, and commercial sectors worldwide (Wang and Azam, 2024). As a result of the global energy shortage, coupled with increasing cost of energy, and more stringent regulations on the release of harmful substances and gases into the environment, there is growing interest on developing renewable energy options to meet the electricity demand for both urban and rural communities (Mohammed and Saha, 2022).

Nigeria has significant renewable energy resources, including solar, wind, hydro, and biomass. The development of renewable energy in Nigeria can lead to sustainable and inclusive socio-economic development, creating job opportunities and new investments and providing environmentally friendly energy options (Bugaje, 2006). However, despite abundant renewable energy resources, especially solar, which could meet the current and projected power demand in the country, the current electricity generation is heavily reliant on fossil fuels, leading to energy insecurity and a lack of access to electricity for a large portion of the population (Oyedokun et al., 2022). Solar energy, being abundant and permanent, has been extensively utilized by rural dwellers for agricultural processing (Ogunniyi et al., 2023). By developing solar energy conversion systems and implementing necessary technologies and policies, the number of people without access to electricity can be reduced, leading to an eco-friendly environment (Maduabuchi et al., 2023).

To facilitate efficient exploration and utilisation of renewable energy resources in Nigeria, there are challenges to overcome, such as inadequate governmental policy frameworks, unsustainable financial models, and low community ownership of renewable energy projects (Oubda et al., 2022). Additionally, there is a need for concerted efforts through collaborative partnership with stakeholders in the distributed renewable energy (DRE) sector to reach out to the poorest and most remote populations of the country. To date, however, this remains largely unaddressed in energy education, both in Nigeria and worldwide. Consequently, Usmanu Danfodiyo University, Sokoto (UDUS), Nigeria is among the select group of twenty three (23) universities that were competitively selected in the Transforming Energy Access-Learning Partnership (TEA-LP), an African-based organisation funded by UK Aid, supporting universities in African, South Asian and Indo-Pacific regions in delivering new and improved curricula that prepare Master of Science (M.Sc.) graduates to help achieve energy access targets in their respective countries. At the moment, UDUS had successfully adopted the two new TEA-LP developed energy access course i.e. "Local Solutions for Energy Access" and "Appliances for Off-Grid Communities" into its M.Sc. Renewable Energy programme. This paper sets out to share this experience and critically engage with sustainable energy education as a precursor for delivering the future workforce for the energy sector.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. The impact of TEA-LP partnership on the UDUS M.Sc. renewable energy programme

One of the cardinal objectives of the M.Sc. Renewable programme run by UDUS is to produce competent professionals capable of applying renewable energy technologies in solving the energy needs of modern society, especially for applications in rural areas and remote locations. Thus, the two TEA-LP developed energy access courses adopted into the UDUS M.Sc. programme, "Local Solutions for Energy Access" and "Appliances for Off-Grid Communities" agrees well with the main objective of the programme, as well as the mandate and vision of UDUS of providing energy experts to help drive the clean energy access transition. Moreover, UDUS is utilizing a grant of £16,700 secured from TEA-LP in the integration of the two new courses into the M.Sc. Programme, through development of programme webpage, marketing for the revised programme and payment of staff time where necessary.

Furthermore, UDUS was among the 23 new partner universities in attendance at the Transforming Energy Access-Learning Partnership (TEA-LP) sponsored course uptake workshop hosted at the Strathmore Business School, Strathmore University in Nairobi, Kenya from 5 to 9 June 2023, as a prelude to the successful take-off of the partnership. The workshop focused on the uptake of the 3 new Master's level courses developed by the TEA-LP, where participants were introduced to the latest developments in the energy access, in terms of technology solutions, energy demand, socio-economic aspects, business models, financial and policy options as well as environmental considerations. Participants were provided with a general framework to transfer knowledge and skills to contribute to the growing off-grid appliances sector. The two participants from UDUS had acknowledged the positive impact of the training towards their capacity building in the teaching and learning of TEA-LP and broader courses for the progamme.

The students of M.Sc. programme in UDUS have been linked into the network that TEA-LP provides, with unique opportunities to participate in Efficiency for Access Design Challenge (EforA), a global, multi-disciplinary competition that empowers teams of university students to help accelerate clean energy access. The inter-university team of five students is working on a project titled "Design and performance evaluation of a solar-powered DC milking machine for dairy cattle". The concept note and proposed budget for the prototyping grants for the project have been approved by the Challenge team.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Teaching methodologies and contents of the TEA-LP developed courses

A systems thinking approach is being used in the teaching of both courses. Students are introduced to the key actors in the local and regional policies and regulations of energy access and appliances for off-grid communities in the pursuit of SDG 7 (access to affordable, reliable, sustainable and modern energy for all). Furthermore, a case study approach, including analysis of data, and highlighting best and worst case examples of global/regional solutions as well as national/local solutions for energy access are also followed. Each course consists of 6 major topics, and provides for a total of 160 student hours including in-class and out of class hours i.e. total time required for the student to complete a curriculum and achieve the course learning outcomes. Additionally, each of the major topic in the course content is further subdivided into smaller sub-topics that captures the intended learning outcome that are relevant to Nigeria.

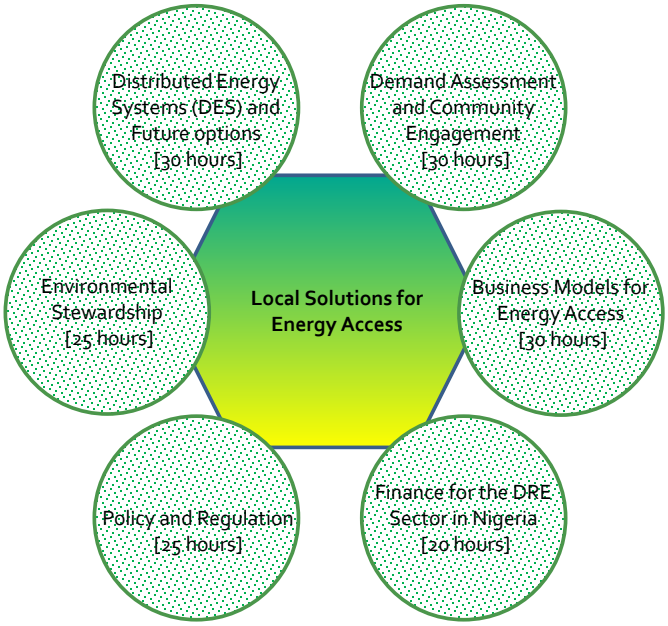
3.1 Local solutions for energy access

Localised energy systems are seen as a viable solution to address the challenges of unreliable and unsustainable electricity supply in Nigeria. These systems can provide jobs and investment opportunities while also improving access to electricity. However, the implementation of localised energy systems in Nigeria in facing challenges and barriers that needs to be addressed. Possible solutions include the deployment of clean and affordable off-grid mini-grid solutions to remote communities, which can unlock their economic potentials (Fasina et al., 2023). Moreover, understanding the status quo of energy access and estimating future energy requirements is crucial. Survey data collected in Nigeria provides valuable insights into demographic and socioeconomic characteristics, energy access, and preferences, which can inform the development of local solutions for access to energy (Pelz et al., 2023).

Local solutions for energy access is a multi-disciplinary course that aimed to provide the postgraduate students with a framework for understanding the off-grid or distributed renewable energy (DRE) sector, while also providing them with the necessary skills and knowledge to assess its challenges and to offer potential solutions for achieving SDG7. The 6 major topics taught in this course are shown in Figure 1.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Major topics in local solutions for energy access course



Source: Own elaboration

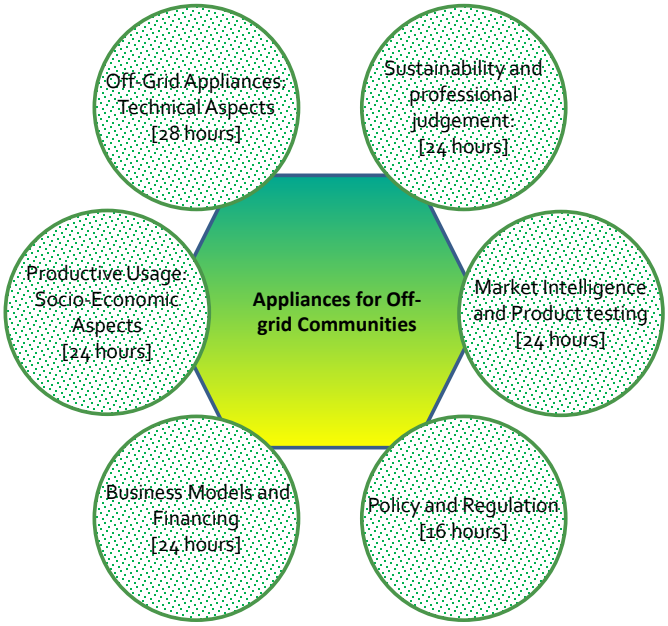
3.2 Appliances for off-grid communities

Off-grid hybrid energy systems with photovoltaic (PV) energy systems, inverters, deep cycle batteries, and electricity generators are commonly used in residential buildings in both rural and urban areas in Nigeria. Moreover, solar home systems (SHS) are another option for off-grid households, providing sufficient energy for their needs and potentially acting as an income source (Audu and Adamu, 2022). On a positive note, governments and international organisations have been providing substantial support to rural electrification projects in Nigeria, with the aim of expanding electricity access to remote areas by implementing off-grid solutions such as solar mini-grids and SHS (Agoundedemba et al., 2023). However, there is a need for more targeted interventions to ensure successful promotion of off-grid appliances and enhance their uptake in Nigeria's off-grid communities.

Appliances for off-grid communities course provides the Masters' level student with the knowledge and skills to map out the environmental, socio-economic, business and application aspects of off-grid appliances to accelerate their diffusion and uptake for household, health and productive uses. The course examines end-user needs such as appliance efficiency, performance, durability, affordability, financing, operation and maintenance. The course consists of 6 major topics presented in Figure 2.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 2 – Major topics in appliances for off-grid communities course



Source: Own elaboration

4. Modalities for localising the TEA-LP courses

The process of adapting the TEA-LP courses into the UDUS M.Sc. renewable energy programme started with a meeting of the Departmental Board of postgraduate studies, where the existing curriculum was reviewed and student hours were reduced by dropping two courses based on some agreed criteria to pave way for the new TEA-LP courses. After the revised curriculum was approved by the University Senate, the department embarked on an extensive marketing campaign using posters, leaflet and social media platforms to attract new students. The programme webpage was also redesigned and valuable information for prospective students were added as suggested by the TEA-LP team (https://www.udusok.edu.ng/m-sc-renewable-energy/). News and updates about the revised programme are being posted regularly on the webpage, and detailed information about the programme, method of application, fees and scholarship opportunities, and contact persons were all provided. As a consequence of our marketing strategy plans, the revised M.Sc. programme received unprecedented number of new intakes for the 2023/2024 academic session.

We recognized the fact that the renewable energy sector in Nigeria has traditionally been considered a male-dominated field, and the presence of women has remained very low across all levels; therefore, a number of sub-topics involving community engagement through field trips and surveys were incorporated in the course contents to allow students to relate closely with women and members of marginalised groups in the community with the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

sole aim of gathering valuable data that will be used to address the issues of gender and social inclusion in the capacity-building activities and access to job opportunities in the DRE sector.

5. The impact of TEA-LP on the target communities

Exploring local solutions in Addressing energy access often means leveraging renewable energy sources such as solar, wind, or biomass. This can lead to reduced dependence on fossil fuels, lowering greenhouse gas emissions, and mitigating the community's environmental impact. For instance, our students had recently developed a high-performing biomass stove for local communities as a transitional or interim solution that can provide some health benefits and significantly reduce environmental pollution. Furthermore, we offer our students opportunities for fieldwork, where they can work directly with communities to understand their unique energy access needs and challenges.

6. Conclusion

In the Nigerian context, where energy access remains a significant barrier to development and quality of life for millions of people, adopting collaborative and locally-driven solutions is not just beneficial, but it is essential. TEA-LP could play a crucial role in addressing the problem by fostering knowledge exchange, capacity building, and innovative problem-solving among stakeholders. The exploration of local solutions not only ensures that interventions are contextually relevant but also promotes community ownership and sustainability.

Acknowledgements

The authors graciously acknowledged the financial support provided to Usmanu Danfodiyo University Sokoto by The University of Cape Town (UCT) (funded by UK Aid through the Carbon Trust) for the Transforming Energy Access–Learning Partnership (TEA-LP) to support the uptake of the two TEA-LP courses.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Agoundedemba, M., Kim, C., & Kim, H.-G. (2023). Energy Status in Africa: Challenges, Progress and Sustainable Pathways. *Energies*, 16, 7708. https://doi.org/10.3390/en16237708.

Audu, H., & Adamu, A. (2022). Expanding energy access in rural off-grid communities: a study on household adoption and affordability of solar home systems in Kwara State, Nigeria.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Journal of Global Economics and Business, 3(11), 181-201. https://doi.org/10.58934/jgeb.v3i11.166.

Bugaje, I. M. (2006). Renewable energy for sustainable development in Africa: a review. *Renewable and Sustainable Energy Reviews*, 10(6), 603-612. https://doi.org/https://doi.org/10.1016/j.rser.2004.11.002.

Fasina, E. T., Adebanji, B., & Adewale, A. (2023). Integrating localised energy systems into the Nigerian power network. *Global Journal of Engineering and Technology Advances*, 15, 001-007. https://doi.org/10.30574/gjeta.2023.15.1.0061.

Maduabuchi, C., Nsude, C., Eneh, C., Emmanuel, E., Okoli, K., Emmanuel, I., Idogho, C., Waya, B., & Harsito, C. (2023). Renewable Energy Potential Estimation Using Climatic-Weather-Forecasting Machine Learning Algorithms. *Energies*, 16, 1603. https://doi.org/10.3390/en16041603.

Mohammed, M. L., & Saha, B. (2022). Recent Advances in Greener and Energy Efficient Alkene Epoxidation Processes. *Energies*, 15(8). https://doi.org/10.3390/en15082858.

Ogunniyi, O., Oni, T., Ikubanni, P., Aliyu, S., Ajisegiri, E., Ibikunle, R., . . . Elewa, R. (2023). Prospects for Nigerian Electricity Production from Renewable Energy. *2023 International Conference on Science, Engineering and Business for Sustainable Development Goals (SEB-SDG)*. https://doi.org/10.1109/SEB-SDG57117.2023.10124504.

Oubda, D., Ouedraogo, S., Diasso, A., Marcel, K., Zougmoré, F., Koalga, Z., & Frédéric, O. (2022). Renewable Energies in Africa, Context and Socio-Economic Challenge. *Open Journal of Applied Sciences*, 12, 1856-1872. https://doi.org/10.4236/ojapps.2022.1211128.

Oyedokun, J., Fasina, E. T., Adebanji, B., & Adewale, A. (2022). Electricity challenges in Nigeria: Renewable energy a way forward. *Global Journal of Engineering and Technology Advances,* 11(03), *016–023*. https://doi.org/10.30574/gjeta.2022.11.3.0085.

Pelz, S., Chinichian, N., Neyrand, C., & Blechinger, P. (2023). Electricity supply quality and use among rural and peri-urban households and small firms in Nigeria. *Scientific Data*, 10(1), 273. https://doi.org/10.1038/s41597-023-02185-0.

Wang, J., & Azam, W. (2024). Natural resource scarcity, fossil fuel energy consumption, and total greenhouse gas emissions in top emitting countries. *Geoscience Frontiers*, 15(2), 101757. https://doi.org/https://doi.org/10.1016/j.gsf.2023.101757.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Methodology to Estimate the Decarbonization Potential at the Neighborhood level. Case study: Benicalap, Valencia, Spain

David Alfonso-Solar[a], Carlos Vargas-Salgado[a], Alvaro Manso[a], Carla Montagud-Montalvá[a], Lucía Izquierdo de Andrés[a]

[a] IIE, Universitat Politècnica de València, Camino de Vera, s/n, 46022 València, Spain

Abstract

The Benicalap district, situated on the outskirts of Valencia, is one of the city's densely populated areas with a mix of residential structures, old buildings, and robust public transport connections. Despite its residential nature, private vehicle transit is significant, and with the anticipated construction of a new football stadium, the district faces challenges related to increased transit, emissions, and services. City Hall reports that 12,465 residents are in a state of "vulnerability," and the majority (69% of workers) are employed in the service sector, contributing to a high unemployment rate of 34%. Addressing the energy transition in this context becomes a technical challenge while dealing with a vulnerable population in an expanding tertiary economy, necessitating considerations of fairness and social innovation.

This case study proposes a disruptive solution for urban energy transition in Benicalap through the integration of renewable energy sources at the district level. With a solar potential of approximately 1,650 kWh/kWp, the strategy involves deploying local energy communities, nature-based solutions, retrofitting buildings, and electrifying transportation. The impact of these solutions is assessed in terms of energy savings and emission factors. The project aims to establish a methodology for estimating decarbonization potential at the neighborhood level and developing a roadmap to achieve decarbonization goals in Benicalap.

Keywords: Decarbonization of cities; Carbon-neutral districts; Emissions inventory; Urban energy transition; CO_2 emissions.

How to cite: Alfonso Solar, D.; Vargas Salgado, C.; Manso, A.; Montagud Montalvá, C.; Izquierdo de Andrésa, L. (2024), Methodology to Estimate the Decarbonization Potential at the Neighborhood level. Case study: Benicalap, Valencia, spain. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 332-339. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The Benicalap district is located on the outskirts of Valencia; it is among the city's top 6 most densely populated districts. It is mainly residential, with relatively old buildings and good public transport connections. However, private vehicle transit is also highly relevant. On top of that, Benicalap is expected to host a vital venue: the new football stadium, with the corresponding increase in transit, emissions, and services.

However, according to the City Hall, 12.465 neighbors are in a state of "vulnerability"; most of the population (69% of workers) are occupied in the service sector, and the unemployment rate is 34%. Thus, the energy transition in this district will accomplish an ambitious technical challenge while coping with a vulnerable population immersed in an expanding tertiary economy.

The urban energy transition proposed for this district is a disruptive solution through district-based integration of renewable energy sources and other strategies. The strategy contemplates some actions: deployment of local energy communities, use of nature-based solutions, buildings' retrofitting programs, and transportation electrification. The impact of the solutions is measured regarding their energy savings and emission factors.

Decarbonization methodology and its application to a urban district of Valencia (Benicalap) was selected a lighthouse case study in RES4CITY European project. The objective of this project is to train the professionals with skills to decarbonize cities with real case application studies.

This case study shows how to exploit all the resources available in a district to accomplish a fair energy transition and to make them work together. Pilot experiences like this are essential to standardize processes and accelerate them.

This project aims to develop a methodology to estimate the decarbonization potential at a neighborhood level, and the roadmap to achieve the decarbonization goals in the neighborhood of Benicalap, which is one of the biggest and dense neighborhoods of the city.

To carry out the methodology, state-of-the-art is elaborated, based on the information obtained, an emissions inventory is worked on, and these emissions are quantified. The emissions inventory is carried out by analyzing sectors such as energy, transport, land use, and others. Subsequently, lines of action are proposed with their respective measures for neutralizing these emissions in the different sectors, developed and analyzed from a technical, economic, environmental, and social perspective (Roncero Tarazona, 2023),(Dobbelsteen et al., 2020).

Once the lines of action are developed, an emissions balance is drawn up, evaluating the contribution that each of the focal points of action makes to the decarbonization of the

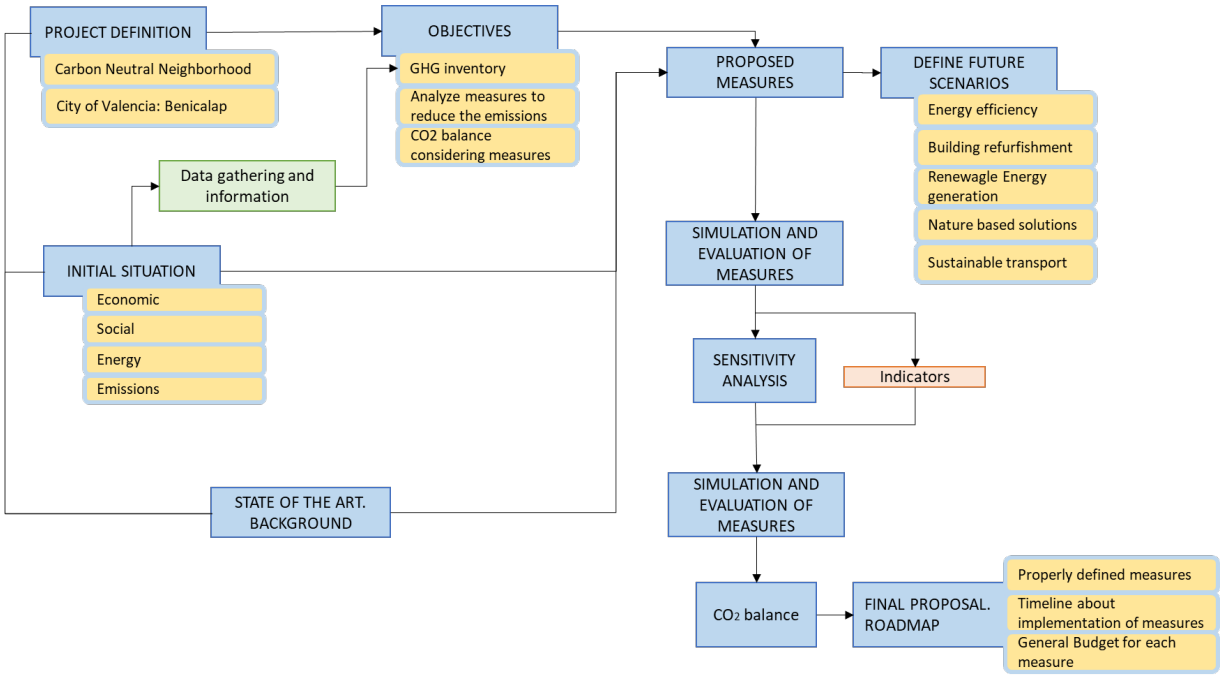
BY-NC-SA 2024, Editorial Universitat Politècnica de València

neighborhood, assessing whether it is possible to achieve the objective of neighborhoods with zero emissions, or if not, including future guidelines to achieve it.

2. Methodology

Figure 1 details the methodology and process used for this project. The first step is defining the project and the planned objectives to achieve during the study. To determine the main project scope and objectives, it is important to plan some questions to bear in mind to define it, such as "What do carbon neutrality plans in your city focus on? What does carbon neutrality mean for your city? What real benefits do you see for your city in implementing these plans? What are the main stakeholder groups the city needs to engage to implement those plans?".

Fig. 1 – Neighborhood decarbonization methodology scheme



Source: Own elaboration

Once the project was defined, a detailed review of the state-of-the-art (SOTA) in different topics related to carbon neutrality was carried out. The documents included and reviewed in this step were, mainly, research articles, sectorial studies and documents related to planning and statistics from the Valencia City Council or the Valencian Community, and reports from the European Community or other institutions (Inventario Nacional de Gases de Efecto Invernadero, 2024). The main topics searched include carbon neutrality, sustainable cities, energy efficiency in buildings, natural-based solutions, circular economy, involving stakeholders in programs, PV generation on rooftops, etc.

The next step is to analyze the initial situation of the place where the project will be applied (Benicalap neighborhood in Valencia city):

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- Neighborhood characteristics: total surface, use of the land, population (quantity, age, gender, job, etc.), urban transport system ((public transport, private transport, car fleet,...)., green areas, and other data. On field visits to the neighborhood were also done.

- Energy consumption per sector (residential, industrial, services, transport,...). For each sector there can be further divisions (electricity consumption, gas consumption, public lighting, ...)

- GHG inventory: the GHG Inventory has been developed considering different groups which are buildings (electricity and gas consumption), transport, consumption of goods, waste and public lighting. Each group can be further divided into sectors or other subdivisions. With data from these activities (electricity consumptions in kWh, distance and type of vehicle, produced waste per inhabitant,...) and specific emission factors, it can be calculated GHG inventory per group or sector.

Considering the initial situation of the neighborhood, and the SOTA review, a list of CO_2 reduction measures has been proposed and evaluated. A brief description of these measures, impact evaluation (CO_2 balance) of its application in the neighborhood and implementation roadmap until 2030, is presented in the results point.

The decarbonization potential refers to the percentage of GHG emissions of the neighborhood (GHG inventory considering scope 1 and scope 2), that can be reduced by implementing proposed GHG mitigation measures.

Collaboration between Valencia city council and UPV, through the Urban Energy Transition Chair (Urban Energy Transition Chair, 2024) since 2020, supports the development of decarbonization methodology described in this work and provides resources such as real data, funding for fellowships and specific studies, and access to specialized software.

Every year 3-5 Students receive six-month fellowships to work on improving the decarbonization methodology, focusing on GHG inventory or new mitigation strategies for city neighborhoods. Their work results in master's theses, contributions to journals or conferences and part of the contents of several on-going PhD thesis.

The methodology is continuously refined and applied to different neighborhoods every year, with students gaining practical experience and contributing to Valencia city's decarbonization efforts.

3. Results

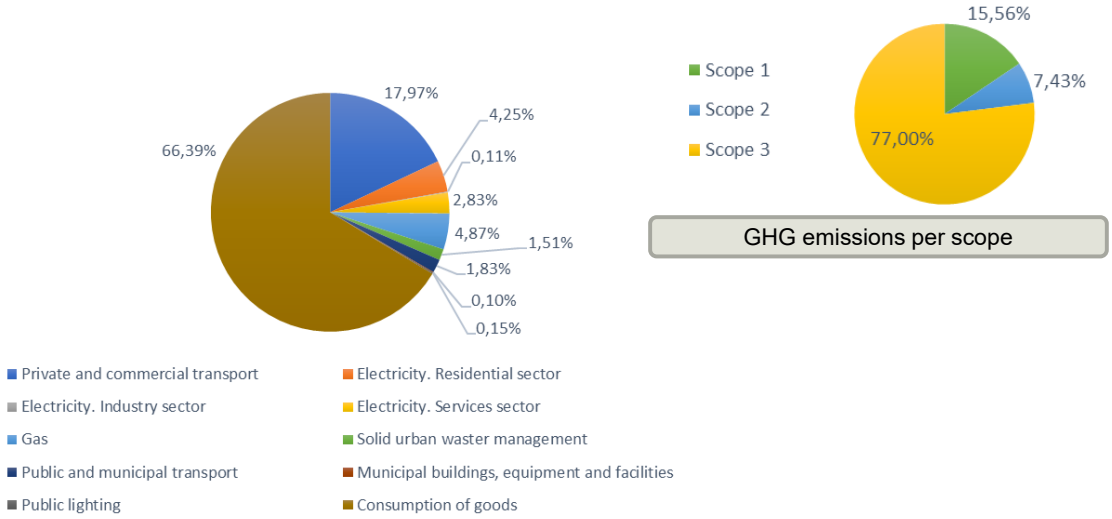
3.1 Initial situation. GHG inventory

With all the information mentioned in the previous point, and following the methodology, the reference GHG inventory of Benicalap neighborhood presents 184,380 tons of CO_2 per

BY-NC-SA 2024, Editorial Universitat Politècnica de València

year. As presented in Fig.2, 77% of the emissions correspond to Scope 3 (indirect emissions), 66.39% being due to the consumption of goods group (food, clothes and other).

Fig. 2 – GHG emissions distribution per group and scope



Source: Own elaboration

Transportation emissions, which account for 18% of total emissions with 33.128 Tons of CO_2/year, is the second main group.

The third group would be building electricity consumption (total residential, services, and industrial sectors), representing 13,259 tons of CO_2 equivalent and corresponding to 7.2% of total emissions (all considered scope 2, as associated to electricity consumption).

3.2 GHG mitigation measures and implementation roadmap

The project's initial phase focuses on scopes 1 and 2 mitigation, so these measures will be further explored and evaluated. The proposed measures and implementation roadmap are described in the following paragraphs, and Fig.3 shows the proposed roadmap for each mitigation measure in more detail.

Nature-Based Solutions

Nowadays, green areas represent de 7,87% of the Benicalap neighborhood area. In previous studies (Laura Gutiérrez et al., 2017), it is recommended to increment green areas for climate change adaptation and mitigation. It is proposed to create new green areas in free spaces based on specific urban panning of the city and/or identification of potential feasible areas. Proposed execution roadmap is 40% of the scope by 2025 and 100% by 2030. CO_2 sequestration per m^2 of urban green areas is based on regional report about carbon stock in the Valencian community(Pardo Marín et al., 2021) .

2024, Editorial Universitat Politècnica de València BY-NC-SA

Public lighting

Current public lighting in different spaces, such as parks, streets, etc., is based on a wide range of technologies, mainly: high-pressure sodium led, LED lights or metal halogen lights. It is proposed to change all public lighting to LED technology according to Fig.3 roadmap.

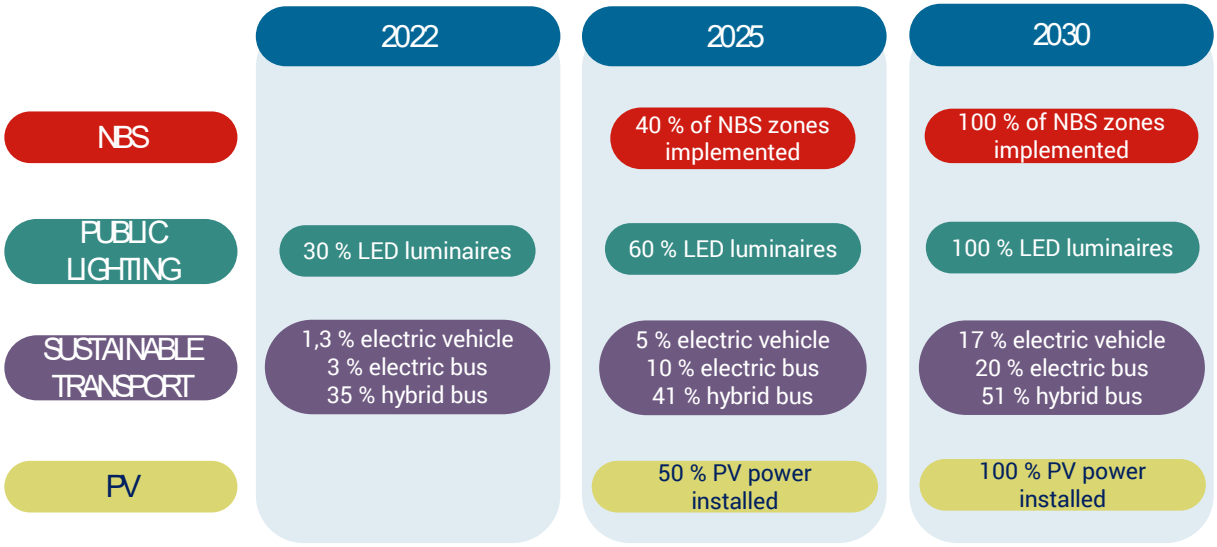
Sustainable transport

A series of measures are proposed for the transport sector based on the "Plan de Movilidad Urbana Sostenible" (PMUS, 2013). Fig.3 shows the implementation roadmap for electric vehicle implementation measures in both private and public transport (which is the highest impact measure). These electric vehicles substitute, mainly, fossil fuel based vehicles according to statistics about present vehicles stock.
Other minor impact measures are also considered as the promotion of pedestrian mobility, increment of bicycle lanes and public bicycles availability, and promotion of public transport.

Photovoltaics (PV)

This proposal consists of installing photovoltaic systems on buildings roof. Roof area estimations, and so potential installable peak power, must be based on specific analysis with QGIS (or other GIS, Geographic Information System, software), and electricity production is estimated using HOMER and PVGIS software. It is determined to install 50% of the power calculated for the year 2025 and reach 100% of this, with a total value of 49,000 kW in 2030.

Fig. 3 – GHG mitigation measures implementation ROADMAP



Source: Own elaboration

Throughout the project period, it is proposed to carry out awareness campaigns to involve and provide greater knowledge to the community about the responsible use of energy,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

recycling, the importance of proximity consumption and other elements that seek a change in the habits of people in favor of sustainability.

A clear, scalable and replicable methodology to determine emissions and abatement potentials will allow to focus on the sectors that generate most significant impact.

Finally, the objective of carbon-neutral neighborhoods, is not only a work that concerns the technical part but also different non-technical factors (legal, social, economic, and policies) that should be analyzed in the near term.

Photovoltaic generation and a more sustainable transportation model are the most relevant measures, achieving a 50% reduction of GHG emissions by 2030.

Fig. 4 – GHG inventory and mitigation measures impact



Percentage of CO_2 savings			
YEAR	2020	2025	2030
NBS	0,051%	0,082%	0,152%
PV GENERATION	0,0%	14,53%	24,87%
PUBLIC LIGHTING	0,0%	0,15%	0,28%
SUSTAINABLE TRANSPORT	0,0%	12,7%	25,39%
TOTAL	0,051 %	27,46 %	**50,69 %**

CO2 SAVINGS: 19884 tCO2/year 50,7%

Source: Own elaboration

4. Conclusion

Sustainable plans, policies, and projects or initiatives like the one presented in this document can play a fundamental role in helping cities and governments to mitigate the effects and adapt to climate change challenges, considering the results obtained in these studies (Covenant of Mayors - Europe, 2024) (H. Gronkiewicz-Waltz, A. Larsson, A. Boni, 2020).

In this project, one methodology to estimate the decarbonization potential was developed to create a roadmap to increase or achieve carbon neutrality.

The GHG emissions inventory was developed at neighborhood level, and it is remarkable that the majority of data was not available at this level, so estimation from city, region or country level data was necessary in many cases.

Scope 3 emissions associated mainly to consumption of goods is the highest responsible of emissions. However, focusing on scope 1 and 2, private transport and electricity consumption in buildings are, by far, the most important groups.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Based on the initial GHG inventory, four measures have been proposed for decarbonizing the neighborhoods: NBS, PV generation, sustainable transport, and efficiency in public lighting. Having developed all these measures, PV generation is the highest contributor to CO_2 emissions, followed by the measures proposed for transport.

Acknowledgements

This work was supported by: a grant of the Cátedra de Transición Energética Urbana- funded by Ajuntament de València-Las Naves and Fundació València Clima i Energia; the RES4CITY project, financed by the European Union under Grant Agreement No. 101075582; the "Innovación y mejora educativa aplicada a los Objetivos de Desarrollo Sostenible en la ETSII" project (PIME/21-22/281), financed by Vice-Rectorate for Organization of Studies, Quality, Accreditation and Languages of the Universitat Politècnica de València.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Covenant of Mayors - Europe. (2024, January 19). https://eu-mayors.ec.europa.eu/en/home

Dobbelsteen, A. Van Den, Roggema, R., Tillie, N., Broersma, S., Fremouw, M., & Martin, C. L. (2020). Urban Energy Masterplanning—Approaches, Strategies, and Methods for the Energy Transition in Cities. Urban Energy Transition, 635–660. https://doi.org/10.1016/B978-0-08-102074-6.00045-0

H. Gronkiewicz-Waltz, A. Larsson, A. Boni, et al. (2020). Proposed Mission: 100 Climate-neutral Cities by 2030 – by and for the Citizens. https://doi.org/10.2777/46063

Inventario Nacional de Gases de Efecto Invernadero. (2024, January 19). https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/inventario-gases-efecto-invernadero.html

Laura Gutiérrez, García, G., & García, I. (2017). 'Soluciones Naturales' para la adaptación al cambio climático en el ámbito local de la Comunidad Autónoma del País Vasco. Guía metodológica para su identificación y mapeo. Caso de estudio Donostia-San Sebastián. 91.

Pardo Marín, R., Lerma Arce, V., Van den Berg, H., Oliver Villanueva, J. V., & Colla Alliaga, E. P. (2021). Cartografía Territorial del Stock de Carbono en la Comunitat Valenciana.

PMUS, V. (2013). PMUS - PLAN DE MOVILIDAD URBANA SOSTENIBLE DE VALENCIA.

Roncero Tarazona, M. (2023). Development of an urban strategic planning tool for carbon neutrality from a district perspective. UNIVERSITAT POLITÈCNICA DE VALÈNCIA.

Urban Energy Transition Chair. (2024, April 17). https://catenerg.webs.upv.es/en/home-2/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Empowering Sustainable Futures: Integrating Experiential Learning in Energy Education Through Local University Exchange Program

Kiran Siraj[a], Munawwar Ali Abbas[b], Nauman Zaffar[a] and Naveed Arshad[a]

[a] Electrical Engineering, Lahore University of Management Sciences (LUMS), Lahore Pakistan

[b] Math Department, University of Baltistan, Skardu, Pakistan

Abstract

This paper introduces a pioneering educational exchange between Lahore University of Management Sciences (LUMS) and the University of Baltistan (UoB), Skardu, aimed at driving sustainable energy solutions in marginalized Pakistani communities and promoting cross-regional knowledge sharing. It offers a model for bridging educational gaps and enhancing socio-economic equity through green energy education. Green energy solutions are pivotal in combating climate change and promoting energy security, especially in areas with limited access to traditional power sources. Methodologically, the program orchestrates a synergy of theoretical classroom instruction and practical fieldwork in Skardu region. We use digital tools and immersive engagement with local energy projects and communities to provide a multifaceted educational experience for students. This approach blends interactive lectures with hands-on, experiential activities to help students understand the challenges of energy access and sustainability in marginalized communities. The efficacy of the program is manifested in the student's improved understanding of sustainable energy concepts, their enhanced problem-solving skills, and their fortified capacity for collaboration across varied cultural and socio-economic backgrounds. Additionally, the empirical data gathered through student-conducted surveys and field research has not only augmented our database but has also been instrumental in advancing numerous clean energy initiatives in Skardu. A salient outcome of the program includes comprehensive student reports and 3D models that exemplify inventive solutions to tangible energy challenges and showcase the understanding of local students towards energy access in Skardu. This paper advocates for a collaborative, experiential learning framework in sustainable energy education. It provides insights for educators, policymakers, and practitioners to promote practical, inclusive, and effective sustainable energy education.

How to cite: Siraja, K.; Ali Abbasb, M.; Zaffara, N. and Arshada, N. (2024) Empowering sustainable futures: integrating experiential learning in energy education through local university exchange program. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 340-349.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Keywords: Sustainable Energy Education; Community Engagement; Cross-Cultural Exchange; Energy Access in Marginalized Areas; Green Energy Solution.

1. Introduction

The 21st century confronts an unprecedented global challenge: the quest for sustainable energy solutions. As environmental concerns are increasing, the need for renewable and sustainable energy sources has become a necessity for ensuring the future of our planet. This urgency is more prominent in marginalised communities, with limited access to sustainable energy, accelerating socio-economic disparities. Innovative energy education is critical in cultivating awareness and empowering the next generation with the knowledge and skills to develop and implement sustainable energy solutions. A more proactive and environmentally conscious society can be created if inclusivity and sustainability are included in educational curricula.

This paper presents a collaborative exchange program between LUMS and UoB, Skardu, aimed at addressing the challenges of sustainable energy education and socioeconomic disparities. The initiative showcases how academic collaborations can foster sustainable practices while bridging educational gaps between privileged and underprivileged areas. It sets a precedent for similar educational models that can be replicated globally. The collaboration known as ***'Learning Without Borders" The Baltistan Experience'*** between LUMS and UoB, marks a significant step in bridging educational and socio-economic discrepancies between marginalized and developed regions. It is a testimony of LUMS's longstanding commitment to inclusive and innovative research and education. The program involved five courses introduced in Skardu, focusing on critical areas such as entrepreneurship, heritage preservation, hospitality management, and addressing climate change impacts. The recurring program engaged more than 100 students and 35 faculty members from both universities. The exchange program's design enabled mutual knowledge transfer, skill development, and resource sharing, benefiting both LUMS and UoB communities. Central to this collaboration is the focus on sustainable energy education, which is crucial for tackling global energy challenges. The Baltistan Experience provided a unique learning setting where nature served as the classroom, enriching students' understanding of sustainable energy in the context of Skardu's rich culture and landscape. This practical, hands-on approach allowed students to immerse themselves in real-world sustainability challenges, fostering a deep understanding of energy access issues in marginalised communities.

The exchange program not only facilitated academic growth but also contributed to developing solutions for local energy challenges, thereby serving as a model for similar educational initiatives aimed at promoting sustainable energy education.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Detailed Map of Pakistan Highlighting Lahore University of Management Sciences, Lahore and University of Baltistan, Skardu.



Source: Own elaboration

2. Literature Review

Recent studies in this area highlight the complexities of implementing sustainable energy solutions in marginalized communities. Key challenges include addressing energy poverty, ensuring equitable access to clean energy technologies, and considering the socio-economic and cultural contexts of these communities. For instance, Sovacool et al. (2022) emphasize the need for inclusive research to facilitate an equitable energy transition, focusing on the integration of marginalised communities within the research framework. A. P. Ravikumar et al.(2023), emphasise the critical role of including marginalised communities in research to ensure an equitable, technology-informed clean energy transition. For just energy transitions, it can facilitate energy access, co-production, energy democracy, and participatory processes besides bringing regional socio-economic development and building community capacity. Mustafa et al.(2023) reveal that in developing countries, the adoption of renewable wind energy is directly influenced by cost value and social influence, while environmental knowledge and health consciousness respectively shape attitudes towards the environment and perceived behavioural control. Furthermore, their research indicates that social influence plays a dual role, enhancing the impact of renewable energy awareness on adoption but diminishing the influence of health consciousness on this adoption process. These insights highlight the critical need for targeted educational programs and policies that

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

address these specific socio-economic and personal factors to effectively promote sustainable energy solutions.

Educational initiatives in sustainable energy have been shown to significantly impact students' understanding and skills related to sustainable energy. These programs often combine theoretical knowledge with practical applications, emphasizing the importance of experiential learning in understanding energy challenges and solutions in real-world settings. Quy Van Khuc et al. (2023) emphasize the critical need to improve energy literacy among Vietnamese youth, demonstrating that despite high environmental concern, there remains a significant gap between perception and action in energy conservation. The study highlights that factors such as gender, income, and rural residency influence the likelihood of pursuing energy education. This underlines the importance of tailored educational programs that consider demographic and socio-economic factors to effectively promote sustainable energy behaviors. Research by O'Shaughnessy et al. (2021) and Carley et al. (2021) sheds light on how such educational programs can foster critical problem-solving skills and a deeper understanding of the socio-economic dimensions of sustainable energy. Social Innovation significantly enhances local energy transitions by promoting participatory governance and co-ownership models, as highlighted in the systematic review by Dall-Orsoletta et al. (2022). Exchange programs, particularly those involving students from diverse cultural and socio-economic backgrounds, have been found to enrich educational experiences significantly. These programs promote cross-cultural understanding and collaboration, essential in addressing global sustainable energy challenges. Leal Filho et al. (2023) investigate the integration of sustainability in global educational initiatives, highlighting the importance of these cross-cultural collaborations in fostering a comprehensive understanding of sustainable energy issues. Experiential learning in the context of environmental education plays a crucial role in enhancing students' engagement and understanding of environmental issues. This approach, which includes field visits, project-based learning, and real-world problem-solving, has been identified as a key factor in fostering a deeper connection with and comprehension of environmental challenges and solutions. Experiential learning in environmental education, as demonstrated by Ho et al. (2022), is vital for fostering a deep understanding of sustainable energy challenges. The interdisciplinary nature of sustainable energy education, which combines insights from various disciplines like engineering, environmental science, and social sciences, is increasingly recognized as crucial for addressing these complex and interrelated challenges. This approach combines insights from various disciplines, such as engineering, environmental science, and social sciences, to provide a holistic understanding of sustainable energy issues. Fatma Widyastuti et al. (2019), underscore the value of interdisciplinary approaches in sustainable energy education. While the studies reviewed illuminate the global importance of sustainable energy education and its multifaceted impact, it's crucial to note that in developing countries like Pakistan,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

collaborative exchange programs like the one between LUMS and UoB are not as prevalent. These types of initiatives are essential for not only bridging the educational divide but also for fostering a deeper understanding and implementation of sustainable energy solutions tailored to local contexts. The LUMS-UoB exchange exemplifies how such collaborations can address specific regional challenges and serve as a model for similar initiatives in other developing regions.

3. Curriculum and Methodology:

This carefully designed curriculum of "Green Energy "integrates a holistic approach, covering a wide range of topics essential for understanding and implementing sustainable green energy solutions, particularly in the context of Skardu's unique environmental and cultural landscape. There were about 35 students from diverse fields including policy, human resources, engineering, and working professionals enrolled in the program.

1. **Types of Energy & Renewable Energy Sources and Energy Generation:** The curriculum starts with a primary knowledge of various energy types, focusing extensively on renewable energy sources including, solar, wind, and biogas, to provide a broad perspective on sustainable energy alternatives. Students also learn how energy is generated and the technicalities involved in operating and maintaining power plants. The basic components of power plants and their mechanisms. This knowledge is crucial for understanding.

2. **Local Energy Context in Skardu:** the core of this course is the understanding of the local energy landscape of Skardu. This includes studying the specific energy needs, resources, and the potential for renewable energy implementation in the region.

3. **Challenges and Battery Storage:** As the Gilgit Baltistan region is not connected to the national grid, electricity is generated mainly using hydro. Due to climate change, the flow of rivers is affected and therefore tackling the intermittency of energy supply battery storage is crucial.

4. **Mathematical Calculations for Energy Projects:** An important aspect of the curriculum involves teaching students to perform mathematical calculations necessary for assessing energy projects. This includes calculating return on investment, solar insolation, wind speed, and other critical parameters for renewable energy projects.

5. **Women's Issues, Health, and Entrepreneurship in Energy:** The program also addresses the intersection of gender, health, and entrepreneurship in the context of energy. Discussions focus on how energy access affects women's health and the opportunities for entrepreneurship in the energy sector.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

6. **Air Quality and Emission Reduction:** The curriculum covers the impact of energy usage on air quality, especially concerning vehicular emissions and the use of solid fuels for heating and cooking. This includes the installation and monitoring of air quality monitors, enabling students to engage in practical data collection and analysis.

4. Teaching Methodology

The teaching methodology of the program is characterized by a dynamic blend of interactive lectures and hands-on, on-site explorations.

I. **Interactive Lectures**: The program features engaging lectures conducted by teachers from both LUMS and UoB. These lectures cover a wide range of topics as discussed earlier and are designed to be interactive, facilitating student participation and in-depth discussion.

II. **Immersive On-site Explorations**: A key feature of the program is the inclusion of field visits to local energy sites, such as hydropower projects. Field visits also include sites of potential renewable energy sites. These visits provide students with practical insights into the real-world application of renewable energy systems, particularly in the hybridization of existing power plants with renewable energy resources to curtail power shortages.

Fig. 2– Classroom and Field Learning in the Skardu Exchange Program.





Source: Own elaboration

III. **Use of Digital Tools for Energy Assessment**: Students learn to utilize online digital tools for assessing the feasibility and potential of renewable energy sources in various geographical areas.

IV. **Hands-on Learning and Practical Application**: The curriculum is designed to ensure that students apply their theoretical knowledge in real-world contexts. This includes opportunities to engage in projects that assess the viability of renewable energy solutions in the Skardu region, such as the hybridization of solar power with existing power plant infrastructures.

Overall, the curriculum and teaching methodology are aligned to provide students with a holistic understanding of sustainable energy, combining theoretical knowledge with practical skills and field experience.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4.1 Key Components and Experiential Learning

4.1.1 Field Visits: The program included field visits to energy sites in Skardu region for practical knowledge of sustainable energy systems. The visits covered hydroelectric power plants, renewable energy potential assessments, and local community interactions. Students learned about hybridizing solar power with hydroelectric infrastructures, assessed the feasibility of renewable energy, and understood the socio-economic context of energy use in the region.

4.1.2 Collaborative Projects: The program included collaborative projects between LUMS and UoB students. The projects aimed to gather data and complement the program's educational objectives. The themes included exploring alternative energy provision methods, identifying indoor pollutant sources, conducting community energy surveys, promoting energy efficiency retrofitting, mapping energy access and equity, conducting energy education and awareness campaigns, and exploring green transportation solutions.

5. Impacts and Outcomes

5.1 Educational Impact: This educational initiative between LUMS and UoB significantly enhanced student's understanding of sustainable energy issues. Key educational impacts include:

I. **In-depth Knowledge of Sustainable Energy**: Students gained an in-depth understanding of the socio-economic and environmental dimensions of sustainable energy, especially in the context of the Skardu region.

II. **Advanced Problem-Solving Skills**: Essential for addressing energy security issues; the program's focus on real-world challenges enabled students to develop critical problem-solving skills.

III. **Cross-Cultural Collaboration**: The initiative fostered collaboration between students from diverse cultural and socio-economic backgrounds making them communicate bilaterally on energy-related issues.

IV. **Comprehensive Reports**: Students compiled detailed reports on their projects, which included thorough data, research, analysis, and recommendations.

V. **3D Model Presentations**: A notable highlight of the program was the creation of 3D models by students. These models visually represented the students' solutions to specific energy challenges, showcasing their ability to translate theoretical knowledge into practical, innovative solutions. The 3D models served as a powerful tool for visualizing the potential impact of these solutions in real-world settings.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

VI. **Skill Development**: In addition to technical skills in sustainable energy, students also developed ancillary skills such as data analysis, digital tool usage, public speaking, and project presentation. These skills are invaluable in their future academic and professional endeavours.

VII. **Utilization of Collected Data**: Importantly, the data collected and analyzed by students has been instrumental in securing grants for clean energy projects in Skardu and similar areas. This data provided critical insights and evidence for the feasibility and necessity of such initiatives, contributing significantly to the region's sustainable development.

Fig. 3 – 3-D Model Presentations by LUMS and UoB Students



Source: Own elaboration

- **Community Impact**: The Green Energy course resulted in impactful projects in Skardu, addressing environmental and health issues and providing sustainable energy solutions tailored to local communities' needs. Notably, the course led to:
- Lift Irrigation Systems: The research and installation of solar-based lift irrigation systems in Skardu, initiated by the Green Energy course, marks a significant advancement in the region's agricultural efficiency and water management. This initiative serves as a replicable model for similar sustainable practices in communities globally.
- Air Quality Revelation and Response: Green Energy students' emission data led to Skardu's first air quality monitors (Fig. 4). It secured funding for clean energy projects, highlighted academics' role in solving environmental issues, and promoted sustainable energy practices.

Fig. 4 –Installation of Skardu's First Air Quality Monitor



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Battery Backup for Hospitals: The provision of battery backups in hospitals, such as the DHQ in Skardu by the LUMS team, ensured that operations could continue without interruption during power outages, significantly improving healthcare delivery and patient safety.
- Energy-Efficient Solutions in Dairy Operations: The installation of Sol-Drive soft starter devices by the LUMS team in milk chillers has led to a significant reduction in energy consumption.
- Solar Dehydrators to Preserve Skardu's Harvest: The region of Skardu, known for its fruits and nuts, has been facing significant food wastage due to unpredictable weather patterns affecting traditional sun-drying methods. Our researchers worked with the community to identify the issue and proposed a Solar dehydrator as a solution.
- These projects exemplify the tangible solutions that arise from educational programs that combine theoretical knowledge with practical application. Through these initiatives, the Green Energy course has made a meaningful contribution to the sustainability and resilience of the Skardu community, underscoring the vital role of education in achieving real-world environmental and social progress.

6. Conclusion

In conclusion, the LUMS-UoB collaborative educational exchange program in Skardu stands as a testament to the power of academic partnerships in driving sustainable energy solutions. Having a holistic framework, combining theoretical knowledge with practical fieldwork, this program not only enriched students' learning but also contributed significantly to Skardu's sustainable energy landscape. As a first-of-its-kind exchange program in Pakistan and integrating sustainable energy into the educational curricula, it offers invaluable lessons for educators, policymakers, and practitioners. The positive response to this initiative highlights the effectiveness of university-community partnerships in aligning academic research with real-world needs, leading to impactful and sustainable outcomes in energy education and development.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Dall-Orsoletta, A., Cunha, J., Araújo, M., & Ferreira, P. (2022). A systematic review of social innovation and community energy transitions. Energy Research & Social Science, 88, 102625. https://doi.org/10.1016/j.erss.2022.102625

Ho, S.-J., Hsu, Y.-S., Lai, C.-H., Chen, F.-H., & Yang, M.-H. (2022). Applying game-based experiential learning to comprehensive sustainable development-based education. Sustainability, 14(3), 1172. https://doi.org/10.3390/su14031172

Khuc, Q. V., Tran, M., Nguyen, T., Thinh, N. A., Dang, T., Tuyen, D. T., Pham, P., & Dat, L. Q. (2023). Improving energy literacy to facilitate energy transition and nurture environmental culture in Vietnam. Urban Science, 7(1), 13. https://doi.org/10.3390/urbansci7010013

Leal Filho, W., Viera Trevisan, L., Dinis, M. A. P., Sivapalan, S., Wahaj, Z., & Liakh, O. (2023). Ensuring sustainability in internationalisation efforts at higher education institutions. International Journal of Sustainability in Higher Education. https://doi.org/10.1108/IJSHE-10-2022-0333

Montañés, C. C., O'Shaughnessy, E., Bednar, D., Nock, D., Carley, S., Kammen, D. M., & Konisky, D. M. (2023). Enabling and centering equity and justice in clean energy transition research. Joule, 7(3), 437-441. https://doi.org/10.1016/j.joule.2023.02.005

Mustafa, S., Zhang, W., Sohail, M. T., Rana, S., & Long, Y. (2023). A moderated mediation model to predict the adoption intention of renewable wind energy in developing countries. PLOS ONE, https://doi.org/10.1371/journal.pone.0281963

Ravikumar, A. P., Baker, E., Bates, A., Nock, D., Venkataraman, D., Johnson, T., Ash, M., Attari, S. Z., Bowie, K., Carley, S., Castellanos, S., Cha, M., Clark, D. L., Deane-Ryan, D., Djokic, D., Ford, J. C., Goldstein, A., Grubert, E., Hu, L., Kammen, D. M., Kosar, U., Miller, C., Pastor, M., & Tuominen, M. (2023). Enabling an equitable energy transition through inclusive research. Nature Energy, 8(1), 1-4. https://doi.org/10.1038/s41560-022-01145-z

Sovacool, B. K., Newell, P., Carley, S., & Fanzo, J. (2022). Equity, technological innovation and sustainable behaviour in a low-carbon future. Nature Human Behaviour, 6(3), 326-337. https://doi.org/10.1038/s41562-021-01257-8

Widyastuti, F., Probosari, R. M., & Saputro, S. (2020, April). Developing environmental awareness through experiential learning: A critical analysis of higher education students' practices. In Journal of Physics: Conference Series (Vol. 1511, No. 1, p. 012098). IOP Publishing.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Enhancing the relevance of vocational training for roofers with novel Sustainable Roofing Methods

Elisa Peñalvo-López[a], Vicente León-Martínez[a], Carla Montagud Montalvá[b] and Iván Valencia Salazar[a]

[a]Department of Electrical Engineering, Universitat Politècnica de València, Spain

[b]Department of Applied Thermodynamics, Universitat Politècnica de València, Spain

Abstract

Roofing is a construction sub-sector with a turnover of approximately EUR 8.8 billion in 2019, and is expected to reach EUR 1.14 billion in 2027, responding to an annual growth of 5%. This growth has been driven by technological innovation, environmental regulations and the opening of new, more environmentally friendly markets. However, this growth has not been supported by the incorporation of skilled labour in the sector, due to the lack of vocational training programmes that are outdated and do not respond to the reality of the sector. As the changing landscape has increased the demand for qualified roofing technicians, the need to equip current and future roofing manufacturers in the sector with new and improved competencies/skills (technical and non-technical) has become more evident than ever.

This article presents the results of the training needs survey carried out in the construction sector,as part of the Erasmus + project called ROTES. This research will serve as the basis for developing a vocational training module that responds to these requirements within the roofing sub-sector.

Keywords: roofing; sustainability; green roofs; construction; VET learning.

How to cite: Peñalvo-López,E.; León-Martínez, V.; Montagud Montalvá, C. and Valencia Salazara, I. (2024) Enhancing the relevance of vocational training for roofers with novel Sustainable Roofing Methods. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 350-358.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The roofing sector, a construction industry sub-sector with an annual turnover of aprox. 80 billion euros in 2019, is projected to reach 114 billion euros by 2027, registering a compound annual growth rate of 4.6% (European Commision, 2020). This growth is primarily fuelled by the emergence of technological innovations, new market niches (eco-friendly materials), and stricter environmental regulations. Nonetheless, the advent of new installation techniques (green roofing, solar panels), computer-aided processes (design software), roofing material upgrades, combined with new product/material requirements (e.g., Construction Product Regulation) and ambitious energy efficiency targets for buildings (e.g., Green Deal - Strategy for a Renovation Wave for Europe) has transformed this "traditional" industry, resulting in new workplace requirements and leading to a shortfall of qualified workers. Roofers have been affected by new technologies, mega-trends and sectoral transformation (Huckstep et al., 2024).

Over 1 million roof workers in Europe exhibit shortages in skills related to new installation techniques and green materials, which are essential to keep up with industry trends, and accommodate for the increasing demand for roof constructions & renovations. Notably, the European Commission (2018) encompasses roofers among the occupations experiencing skills shortages in the EU (Clarke et al., 2024).

The growth of the sector is not supported by an equally stable growth in available skilled labour. Labour shortages rank as a top concern for contractors in the commercial roofing industry, as experienced workers retire and the replenishment level remains relatively low. The industry also notes a gap between the skills/knowledge acquired by workers through VET and especially work-based learning (WBL) that is an indispensable part of sectoral training provision, and those needed in the workplace. Growing talents through a dual VET system (combining vocational education & apprenticeship) is regarded as the most effective and long-term solution to attract young workers and address the prevailing shortage in skilled, qualified technicians.

2. ROTES project

Natural-based solutions are one of the main sustainable strategies for cities to reduce greenhouse emission to the atmosphere and improve the well-being of the citizens (Growgreen project, 2020)(Peñalvo-López et al, 2020). However, the construction sector still lacks of specialized staff to install this green infrastructure as it is a relatively new concept that requires of specific capacity building programmes (Luque et al., 2024) (Battisti et al., 2024)(Peñalvo-López et al., 2023). ROTES (2022) is the first Erasmus+ project to address the emerging training needs of roofers. There has been a number of efforts addressing skill needs in the wider construction industry but none of them have produced curricula specifically

BY-NC-SA 2024, Editorial Universitat Politècnica de València

addressed to the occupational group of roofers, and, in terms of current workplace realities, they demonstrate limited skills coverage and outdated content (where applicable to roofers) (Peñalvo-López et al., 2023).

3. International cooperation

An international multidisciplinary team was created from the development of this Erasmus Plus initiative. The consortium is composed of six organisations with high capacity, qualifications & complementary skills. The expertise brought by each partner, as described below, substantiates the added value of this collaborative endeavour: UPV – Universitat Politècnica de València, PAMB - Polskie Stowarzyszenie Menedzerów Budownictwa, FORMEDIL- Formedil Ente Unico Formazione E Sicurezza, LTT - Liceul Tehnologic Ticleni, EXELIA E.E., and INNOVELA Sprl.

4. Field Research

This section of the article presents the analysis and results of the survey research carried out in ROTES to identify the priorities and training requirements on green and sustainable roofing skills, thereby setting the foundations for the development of the training and assessment material and the ROTES curriculum.

4.1. Purpose and target groups

The structured questionnaire is one of the main instruments for gathering survey data and is often used to establish a structured, organised and well documented way to collect opinion-based evidence and personal views on roofing skills requirements. The questionnaire was structured in a clear and simple manner to encourage participation and facilitate communication with target groups. The questionnaire comprises mostly closed-ended questions as they are easier and quicker for respondents to answer; offer better coding, analysis and comparison possibilities; and can clarify question meaning for respondents through response choices.

This questionnaire addresses the relevant stakeholders to capture their perceptions on skills, knowledge and competences required by construction sector workers to perform green efficient roof making and materials.

4.2. Online questionnaire results

This section presents the data collected via the online questionnaire and summarises the outcomes of the field research data collected by the consortium in the partnership countries (Italy, Poland, Romania, Belgium, Greece and Spain). The data has been analysed collectively in order to obtain aggregate results presented in graphical format, while taking into consideration all available contributions.

2024, Editorial Universitat Politècnica de València BY-NC-SA

4.3. Sampling targets and participation statistics

The total number of survey´s respondents was 187, collected among the six European countries participating in the proyect, as it may be observed in Table 2.

Table 2. Completed questionnaires per consortium country and project partner.

Partner	Country	Completed questionnaires
UPV	Spain	34
PSMB	Poland	25
INNOVELA	Belgium	6
EXELIA	Greece	19
FORMEDIL	Italy	74
LTT	Romania	29
TOTAL	**187**	

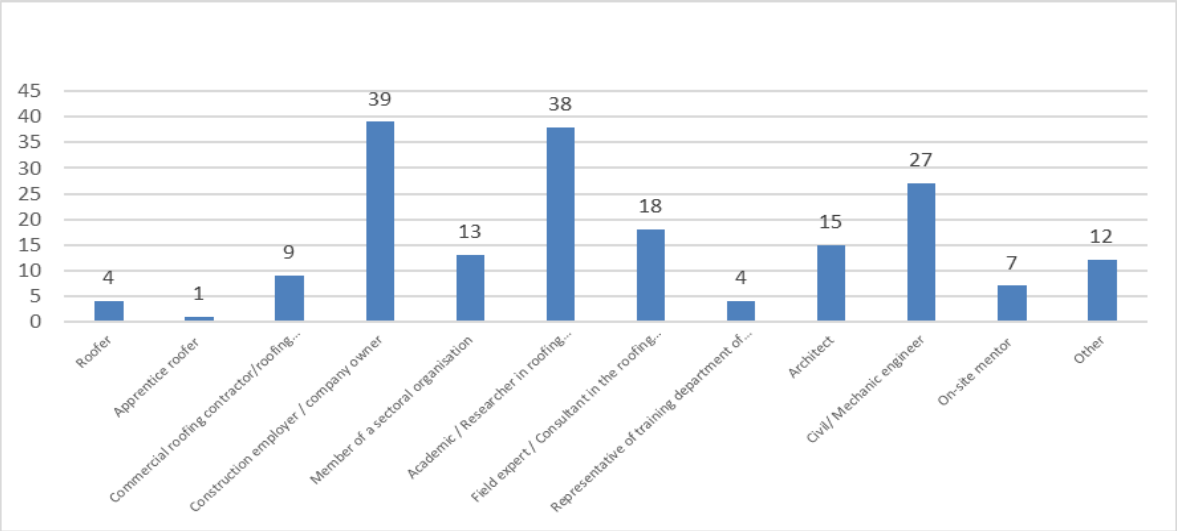
Source: Own elaboration

4.4. Job functions of the respondents

The most represented group were the construction employer/company owner with a total of 39, followed by Academic / Researcher in roofing construction field with 38. It is followed by the civil/mechanic engineer with 27 representatives and the remaining target groups also have significant representation (i.e. field expert/ consultant in the roofing industry, architect, executive/ member of a sectorial organization, commercial roofing contractor).

Regarding the type of organization responding the questionnaires, it may be noted that the majority of respondents are training providers (58) and private roofing companies (37).

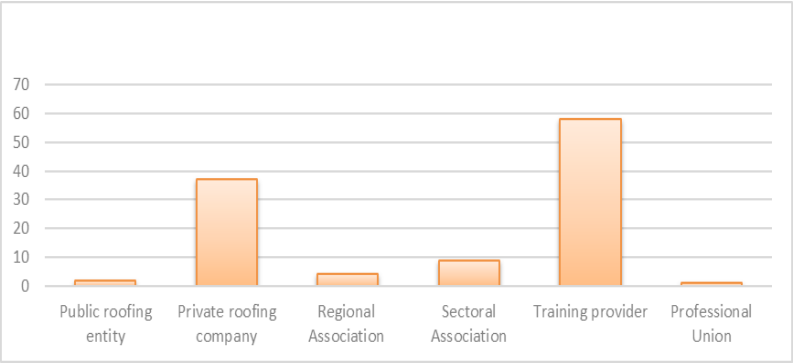
Fig. 2 – Job function of respondents in number



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 3 – Type of organization of the respondants



Source: Own elaboration

4.5. Knowledge/Skill requirements

One of the section within the questionnaire urged respondents to evaluate the importance of necessary knowledge and skills in different categories: Properties of the materials, Materials react to weather conditions, Familiarity with EU & national construction regulations & legislation, Type of sustainable roofing needed, Safety guidelines, Selection of recycled old sustainable materials, and Recruitment challengues.

- **Properties of the materials**

Regarding the question "to what extent do green & digital roof making need to be knowledgeable on properties of different types/categories of sustainable materials used in the roofing sector (e.g. wood, clay, concrete, slate, metal, etc.)", 89% of the total respondents considered it to be of very high or high importance, while 9% only considered it to be of average importance. Low and very low importance represent 2% of the total responses (Fig 4).

- **Materials react to weather conditions**

The statement "to what extent do green & digital roof making need to be knowledgeable on green and sustainable roofing materials behave & react to weather conditions", proved to be of very high importance for more than 50% of the total respondents. A further 35% of participants also considered this statement of high importance and a very small fraction of respondents considered this statement of average low or very low importance (Fig. 5).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig.4 – Importance of knowledge regarding different properties of materials

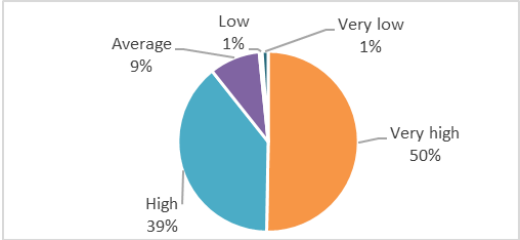
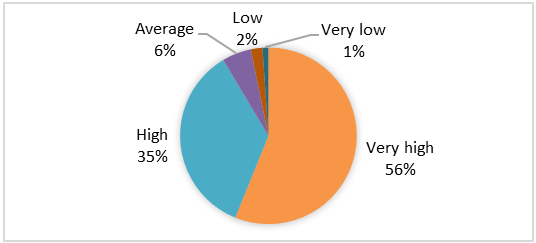


Fig. 5 – Importance of knowledge on green and sustainable roofing materials behave & react to weather conditions.



Source: Own elaboration

- **Familiarity with EU & national construction regulations & legislation**

Related to the European and national construction legislations and frameworks, the majority of the respondents (86%), considered the question "to what extent do green & digital roof making need to be knowledgeable on EU & national construction regulations & legislation" of very high and high importance, while only the remaining 14% consider it to be average, low or very low importance (Fig. 6).

- **Type of sustainable roofing needed**

Analysing the responses to the statement "In your experience, to what extent do green roof professionals need to have the skills to determine the amount and type(s) of sustainable roofing needed, based on factors such as location, surface shape and equipment use, energy efficiency etc.", we can observe that the large majority of respondents thinks that it is very high and high importance (Fig. 7).

Fig.6 –Importance of familiarity on EU & national construction regulations & legislation

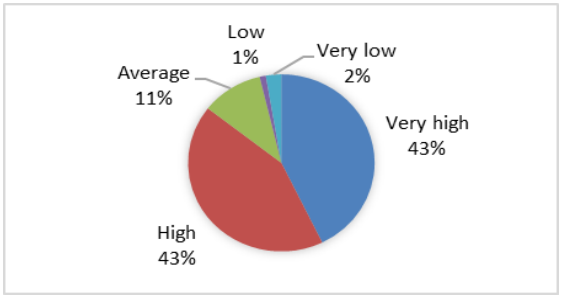
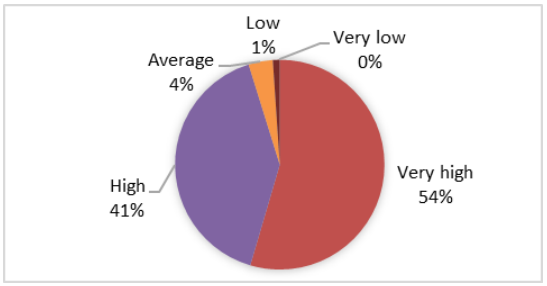


Fig.7 –Importance of skills to determine the amount and type(s) of sustainable roofing needed



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- **Safety guidelines when installing green roofing materials**

According to the respondents, the concept it is very important to follow safety guidelines when installing green roofing materials. 95% considered very high and high importance.

- **Selection of recycled old sustainable materials**

Regarding the statement "In your experience, to what extent do green roof professionals need to have the skills to suitability of selection of recycled old sustainable materials" 90% of the total respondents, considered the ability to select the appropriate materials is important. The remaining 10% consider it to be average or low importance. No one considers it very low importance.

Fig.8 – Importance to follow safety guidelines when installing green roofing materials

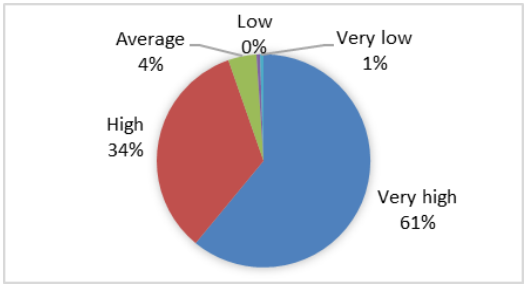
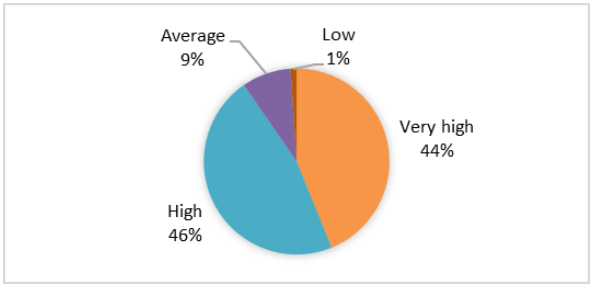


Fig.9 – Importance to selection appropriate materials

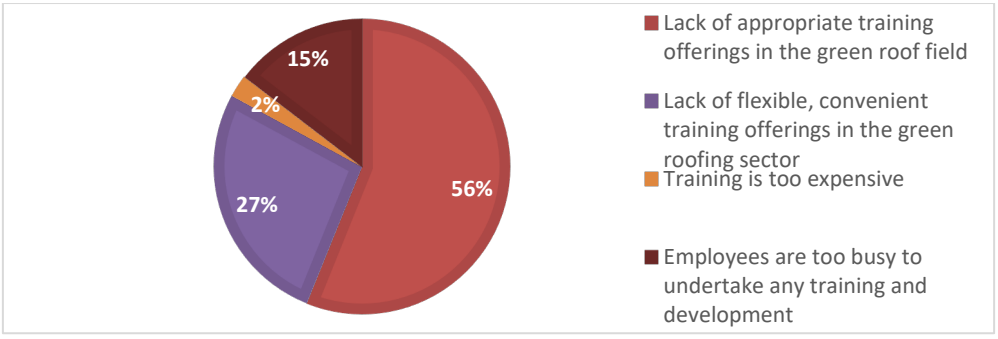


Source: Own elaboration

4.6. Main barriers to providing green roof making specialized training

Finally, participants were asked about the barriers to provide green roof tailored training to the workforce. In this regard, response with the highest representation was "the lack of appropriate training offerings in the green roof field".

Fig.10 – Main barriers to provide specialized training



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

5. Conclusions

As a conclusion of the survey of 187 respondents, we can state that they consider very important all the knowledge and skills required of roofers. All options on whether they considered knowledge and skills related to green roofs to be important had a significantly percentage of respondents that considered "very high" or "high" of importance.

What emerges from the analysis of this survey is that companies are facing problems in recruiting green roofers and therefore there is a need for more experts in the sector with the required skills and this is mostly due to Lack of adequate training offers in the field of green roofing. Hence, is necessary to increase the supply, quality & relevance of vocational training for roofers.

Acknowledgements

This work has been carried out within the framework of the research project ROTES "Enhancing the relevance of vocational training for roofers with the latest industry standards" funded by the European Comission within the Key Action 2: Cooperation partnerships in vocational education and training, reference number: KA220-VET-F1EC8E27.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

European Commission, Country Report Reports 2020. February 2020. Online. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020SC0506&from=EN

Huckstep, S., & Dempster, H. (2024). Meeting Skill Needs for the Global Green Transition. https://www.bosch-stiftung.de/sites/default/files/publications/pdf/2024-02/meeting-skill-needs-global-green-transition-role-labour-migration.pdf. Online accessed on February 2nd.

Clarke, L., Sahin-Dikmen, M., Winch, C., Price, V., Calvert, J., Bilodeau, P. L., & Dionne, E. (2024). Differing approaches to embedding low energy construction and climate literacy into vocational education and training. In Routledge Handbook on Labour in Construction and Human Settlements (pp. 76-96). Routledge.

Peñalvo-López, E., Andrada-Monrós. C., Montagud-Montalvá, C. (2023). Research on Learning Outcomes for a novel roofer´s educational training programme. In the 11th International Conference on Innovation, Documentation and Education (INNODOCT 2023). (1 - 10). Bucaramanga, Colombia: Latin America.

Grow Green Project - H2020. (2020). Compendium of Nature-based and 'grey' solutions to address climate- and water-related problems in European cities.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Peñalvo-López, E., Cárcel-Carrasco, J., Alfonso-Solar, D., Valencia-Salazar, I., & Hurtado-Pérez, E. (2020). Study of the Improvement on Energy Efficiency for a Building in the Mediterranean Area by the Installation of a Green Roof System. Energies.

ROTES Project. (2023). Enhancing the relevance of vocational training for roofers with the latest industry standards. Retrieved from https://www.rotes-project.eu/

Luque, G. P., & Arpon, J. C. (2024). Newly created ecosystems for a green built environment: Green roofs and green walls/facades. Nature-Based Solutions, 100111.

Battisti, A., & Calcagni, L. (2024). Avant gardening to grow the green city. In Beyond the Garden (pp. 25-38). Springer, Cham.

Peñalvo-López, E.; León-Martínez, V.; Graña Lopez, M.A. (2023). Upskilling city policy makers and decision makers in Natural Based Solutions as a means for tackling air pollution and climate challenges in the cities. EN 11th International Conference on Innovation, Documentation and Education (INNODOCT 2023). (1 - 7). Bucaramanga, Colombia: Latin America.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Entrepreneurial Ecosystem in Higher Education: A Systematic Insights for Sustainable Energy Engineering Education at the University of Port Harcourt

Tobinson A. Briggs[a,b] and Endurance Ogheneruona Diemuodeke[a,c]

[a] Department of Mechanical Engineering, Faculty of Engineering, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

[b] Technology Park, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

[c] Energy Technology Institute, Faculty of Engineering, University of Port Harcourt, PMB 5323, Choba, Port Harcourt, Rivers State, Nigeria

Abstract

Entrepreneurs are critical in the diffusion of clean energy technologies to support the energy access sector. The entrepreneurs in the energy access industry are mainly engineers or collaborating with engineers because of the desire to provide innovative energy solutions to drive the energy access sector. Therefore, this paper presents the development of an entrepreneurship course and curriculum to provide engineering students with the holistic sets of entrepreneurial skills and competencies to adequately respond to the growing energy access sector of sub-Saharan Africa using clean and sustainable energy technologies. The study provides the procedure used to develop a course "Entrepreneurship and Management" under the MSc Energy Access and Renewable Energy Technology programme at the University of Port Harcourt and the teaching and learning aspects of the course. The MSc programme provides non-gender-biased high-level energy professionals with competencies and skills to navigate complex challenges in the energy access sector, with a focus on providing students with real-world experience and action to support of livelihood. The preliminary impact of the course is presented.

Keywords: ecosystem entrepreneurship; entrepreneurship education; curriculum; sustainable energy education; sustainable entrepreneurship

How to cite: Briggs, T.A and Diemuodeke, E.O. (2024) Entrepreneurial Ecosystem in Higher Education: A Systematic Insights for Sustainable Energy Engineering Education at the University of Port Harcourt. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 359-367. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the sub-Saharan Africa (SSA) context, the literature has enumerated several barriers to sustainable energy to adequately respond to SDG7. The lack of capacity of local experts to drive the energy access sector with the right skills and competencies was rated high in much of the literature (Sokona, 2021; Pailman and de Groot, 2022). Therefore, there was a need to build the capacity of local professionals to provide and manage clean energy technologies to adequately respond to the growing energy access sector of the SSA. In this context, capacity building is the development of a set of skills and competencies to effectively provide context-sensitive innovative energy solutions and an impeccable institutional framework to effectively implement and manage the innovations. However, entrepreneurs are critical in the diffusion of clean energy technologies to support the energy access sector.

Notwithstanding, the National Universities Commission (NUC) advocates for the introduction of entrepreneurship courses and skill sets in the training of young engineers. In the spirit of NUC, the University of Port Harcourt positioned itself as an entrepreneurial university with the establishment of an entrepreneurial centre. The centre aims to serve as a vehicle to link theory and practice with economic ventures by providing students with an entrepreneurial mindset before graduation (Chikere, 2023). However, the entrepreneurial programmes at the University of Port Harcourt do not adequately provide the students with the right skills and frameworks to address the emerging clean energy access sub-sector.

It was, therefore, necessary, and imperative to develop an entrepreneurship course and curriculum to provide the students with the holistic sets of entrepreneurial skills and competencies to adequately respond to the growing energy access sector of the SSA using clean and sustainable energy technologies. The students must have both technical and entrepreneurial sets of skills to provide local-sensitive innovative energy solutions with socio-economic benefits. The entrepreneurs in the energy access industry are mainly engineers or collaborating with engineers because of the desire to provide innovative energy solutions to drive the energy access sector.

This study provides the procedure used to develop a course "Entrepreneurship and Management" under the MSc Energy Access and Renewable Energy Technology programme at the University of Port Harcourt and the teaching and learning aspects of the course. The MSc programme provides non-gender-biased high-level energy professionals with competencies and skills to navigate complex challenges in the energy access sector, with a focus on providing students with real-world experience and action to support livelihood.

2. Methodology

The curriculum development started with a needs assessment workshop, which gathered energy entrepreneurs and academic experts along with government personnel to obtain

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

critical insights into the entrepreneurship ecosystem in Nigeria. The outputs of the needs assessment workshop were critically analysed against available data sourced from literature in the open domain. Furthermore, entrepreneurs who work in the energy access sector of Nigeria were interviewed to gain critical insight into the expectations of an energy entrepreneur and the Nigerian entrepreneurship ecosystem. In addition, a conceptual model/framework that precisely links the institutional ecosystem with lecturers, energy practitioners and government personnel involvement was identified. The methodology captures the implications for positive social change including the potential for sustainable energy entrepreneurs to increase their success rate, leading to improved political economy of livelihood for an increased standard of living of people in the local communities through increased job stability and a lower unemployment rate.

The teaching and learning of the Entrepreneurship and Management course involve student-centred-based course delivery laced with the Triple Helix Plus model (Fidanoski, et al. 2022) and internship. The Triple Helix Plus is a course delivery model that involves the collaboration between university, industry, government, and professional bodies/associations. The Triple Helix model promotes a sustainable entrepreneurial ecosystem which encapsulates various factors such as politics, finance, markets, culture, human capital, and support (Isenberg, 2011). The internship introduces the students to a critical understanding of the energy access ecosystem and the identification of opportunities.

2.1. Harnessing Inputs for the Course Design

One of the dominant methodologies used in gathering input for designing and making decisions on the entrepreneurship and management course content is design thinking, which significantly enhanced entrepreneurship training (Sassetti, et al., 2022; Linton and Klinton, 2019). In order to implement this concept a multidisciplinary and trans-disciplinary workshop and stakeholders' meeting were held with all stakeholders from the universities, industries, government agnecies, and professional bodies/associations to achieve the following:

i. Needs Assessment Workshop: This was done by inviting stakeholders to a workshop and engaging with the stakeholders, including government angencies, lecturers, industry experts, and entrepreneurs. Paper presentation were made in the workshop and followed by interviews targeted at the critical stakeholders to understand nuances of clean energy technologies and energy entrepreneurship.
ii. Collaborative brainstorming sessions: During the stakeholders' engagement workshop, critical stakeholders were invited to share their ideas, insights, and innovative approaches to effectively engage students within the delivery period of the entrepreneurship course. An extensive array of ideas were generated which streamlined the course content outline.
iii. Curriculum formulation: The course curriculum was formulated with its essentials, such as the course objectives, intended learning outcomes, course content, proposed teaching

BY-NC-SA 2024, Editorial Universitat Politècnica de València

techniques and materials, and the assessment and examination. The course curriculum was tested with a cluster of stakeholders to ascertain its effectiveness, applicability, and alignment with the course objectives and the intended learning outcomes.

iv. Collaborative course content creation: In the stakeholders' engagement workshop, professionals from the universities, industries (including energy entrepreneurs), government angencies, and members of professional bodies/associations were invited to share real-world case studies or industry challenges, and also to show how the case studies should be implemented in the curriculum. This collaborative effort in the course content informed the model of students' design practical exercises, simulations, and projects that reflect entrepreneurial situations.

2.2. Students' Engagement Approach

The engagement of students in the course (Entrepreneurship and Management) has meaningfully enhanced their critical thinking about the dispersal of clean energy technologies with the following experiential explanatory examples:

i. The use of a Project-Based learning approach: Students of different physical sciences and engineering backgrounds were admitted into the MSc programme at the University of Port Harcourt. This mixed background of students gave them the platform to work on projects that are related to clean energy circumstances, which allowed them to engage in problem-solving, market dynamics analysis, and deliberate on sustainable solutions. The concept of project-based learning has encouraged and cultivated critical thinking by challenging students to identify opportunities, consider multiple perspectives, learn from mistakes, and adapt their methods as the needs arise (Gillett and Kelterborn, 2022).

ii. The use of Interdisciplinary and multidisciplinary Deliberations: The diverse physical science and engineering backgrounds of the students in the programme created an atmosphere for the students to engage in interdisciplinary and multidisciplinary dialogues and thoughts concerning clean energy diffusion. These levels of interaction and thoughts expose the students to perceptions, encouraging critical analysis of clean energy technological, cultural, social, economic, and environmental factors (Berry,2022).

iii. Engaging students with related case studies: During the lecture delivery students were challenged with case studies related to clean energy scenarios such as successful ventures, startups, or implementation of energy business policy. Engaging students with such tasks gives them practical insights, where they learn how to evaluate challenges, carry out risk assessment, and profound innovative solutions. Hence, the emergency of critical thinking as the students dichotomize the complex situations and cogitate multiple variables (Gillett and Kelterborn, 2022).

iv. Industry visits and Expert Resource Persons: The programme curriculum accommodates industry and rural community visits with the students. Such visits allow the students to identify problems associated with clean energy adoption, where the students are engaged in

2024, Editorial Universitat Politècnica de València BY-NC-SA

asking questions, discussions, and benefits from practical knowledge. Also, they get exposure from industry clean energy facilities as it relates to real-world perspectives (Gillett and Kelterborn, 2022).

v. students' research workshop and innovation competition: The students' research workshop on renewable energy creates a forum for them to discuss and defend their viewpoints, engage in counterarguments, and evaluate evidence. This concept challenges their perspective, improves their analytical skills, and fosters critical evaluation of diverse viewpoints. Secondly, we encourage students to participate in innovation competitions. This kind of competition exposes the students to analyse cases to identify major factors and business model that influence clean energy diffusion. It also helps the students to simulate decision-making scenarios, market simulations, and policy negotiations (Gillett and Kelterborn, 2022).

2.3. Evaluation of Students on the Course

The students were evaluated in the entrepreneurship and management course based on their understanding, skills, and the application of entrepreneurial concepts that aligned with the course objectives and the intended learning outcomes. Here are some assessment methods applied in the evaluation of the students:

i. Class attendance: students are strongly encouraged to regularly attend lectures because that reflects students' engagement and participation in the course. Points are awarded accordingly.

ii. Class assignments and participation: students are given class exercises such as an assignment on business plans, feasibility studies, market research, business canvas, and project reports which engage the students actively in discussions and group activities.

iii. Assessment by peer group: as part of the continua assessment the students evaluate each other's case studies or group projects. This exercise encourages teamwork and promotes self-awareness.

iv. Journals and Portfolio Reflection: in order to deepen learning students are encouraged to reflect on their learning journey, growth, challenges, entrepreneurial experiences, and areas of improvement through maintaining journal and portfolio reflections.

v. End of course examination: students are subjected to the end of the course to assess their understanding of the vital concepts which cover areas like financial modelling, profitability analysis, organisational behaviour, business risk analysis and management plan, and business models.

2.4. Some Difficulties or Challenges faced by the Students and Entrepreneurs

As exhilarating and demanding as the course is, there were some difficulties or challenges faced by students and potential entrepreneurs which are given below.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

i. Understanding institutional Intellectual Property (IP) policy: One of the major challenges faced by students and potential entrepreneurs is to understand the intellectual property (IP) policy of the institution. The institutions need to write their intellectual property policy in very plain language and make it available so that the students and potential entrepreneurs will have a deep understanding of IP policy. By doing so, it will drastically reduce conflict in the long run since students are not naturally considered employees of the institutions.
ii. Product Perfection: Students have fantastic ideas, but having the ability to perfectly execute these ideas into acceptable products or services is a major challenge. Students sometimes battle to understand the sophisticated technology behind their inventions or innovations.
iii. Balancing the completion of their degree and venture: Students or potential entrepreneurs struggle to manage the activities innovations or innovative products while undergoing their studies because being an entrepreneur is a time-consuming task and often takes all the energy of the students.
iv. Having financial constraints: Another major challenge student entrepreneurs are faced with is securing adequate funding to finance their innovations or innovative products, mostly during their studies in school. Students are encouraged to think outside the box to secure funding which becomes an important task.
v. Challenges in building a Network: Many student entrepreneurs finding difficult to build a network where students will be connected with potential collaborators, mentors, and possibly industry professionals. Building a strong network is crucial for entrepreneurs' growth.

3. Results and Discussion

The study shows that the entrepreneurship course is important in driving sustainable energy education because the entrepreneurs are critical in the diffusion of clean energy technologies to support the energy access sector, which in turn excites the local economy for sustainable livelihood. The course content, facilitator and learning activities are presented in Table 1.

The delivery of the Entrepreneurship and Management course started in 2022, with two cohorts of students completing the course. The students from the MSc Energy Access and Renewable Energy Technology have two start-up companies in the energy access sector, which is primarily due to the Entrepreneurship and Management course and have registered with the University of Port Harcourt Technology Park. One of the start-up companies is Tovero Energy (https://toveroenergy.com/), with the following services energy planning, energy audit, energy advisory, mini-grid design, clean cooking solutions, energy systems design and development, and energy education and advocacy.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Structure of the course

Content (facilitator)		Student learning activity – type
1.	Innovation-driven enterprise entrepreneurship and technology diffusion (University)	Pre-reading; class discussion; watch videos, case study
2.	Opportunity identification (University/Industry)	Case study
3.	Market segmentation (Industry/Professional bodies)	Roleplay, class discussion
4.	End-user profile (Industry/professional bodies)	Advance reading, class discussion
5.	Total addressable market size (Industry)	Advanced reading, class debate
6.	Business risk analysis & management plan (competitive positioning) (university/industry)	Explore shared topics, video games, case study
7.	Customer's Decision-Making Unit (University/Industry/Professional bodies)	Reading, group assignment
8.	Financial modelling and profitability analysis (University)	Pre-reading, class exercise, case study, class discussion
9.	Managing Cash flow (University)	Roleplay, Individual assignment
10.	Business model development (University/Industry)	Advanced reading; online video, case study, group discussion
11.	Product/project development plan (Industry/University)	Advance reading, demonstration
12.	Business law and regulations (Government/Professional Bodies)	Case study, Group assignment
13.	Regional and National Policies that impact the uptake and sustainability of clean energy appliances (Government/Professional bodies)	Case study, Group assignment

Source: the authors

To effectively support start-ups, the Entrepreneurship and Management course influenced the University of Port Harcourt to design a framework, through the Technology Park, for the start-up formalisation process. First, the intention of support and registration is made to the University Technology Park by the student. Second, the start-up is screened and evaluated for innovation and market value. Thereafter, suppose the screening and evaluation outcome is positive, the University Technology Park supports the student in registering the start-up with the Corporate Affairs Commission (CAC) – which is the legal body that registers enterprises and companies in Nigeria. Three companies from the MSc Energy Access and Renewable Energy Technologies programme are in the process of registering their companies with the CAC.

3.1. Results on the implementation of the course

The Entrepreneurship and Management course pays strong attention to entrepreneurial firms related to clean energy technology, with an emphasis on managing innovations for both small and large enterprises. The course is tailored in a way that helps student entrepreneurs to achieve their career goals. Some of the results of implementation of the course are as follows:

BY-NC-SA 2024, Editorial Universitat Politècnica de València

i. At the end of the course, students were able to identify, recognize and understand why some innovative ideas would not be commercially worthwhile.
ii. Engaging students in hands-on projects and live cases during the lecture delivery has given the students the platform to gain experience in venture dynamics, entrepreneurial marketing, entrepreneurial financing, and the importance of entrepreneurial networking.
iii. The course Entrepreneurship and Management are equipped with relevant skills for the students to gain insights role of innovation in new ventures and large organisations, and the ability to navigate the entrepreneurial landscape.

Furthermore, during the delivery of the course, students were engaged and encouraged to ask questions for clarity and propose new and better ways of doing things. This action collaborates with the fact that Entrepreneurship is not only about coming up with new products and services but also about questioning established ways of creating value in the market by redesigning the processes.

4. Conclusion

There was a need to build the capacity of local professionals to provide and manage clean energy technologies to adequately respond to the growing energy access sector of the SSA, with a course in Entrepreneurship and Management as the transformative catalyst for the diffusion of clean energy technologies to support the energy access sector. Therefore, the paper presents the methodology used in the development of an entrepreneurship and management course curriculum and teaching and learning models at the University of Port Harcourt. The implementation of the course has produced two startup companies with an additional three companies undergoing registration with the Corporate Affairs Commission of Nigeria. The course addresses the National Universities Commission's entrepreneurship education and responds to the need to adequately drive the clean energy access sector of Nigeria, SSA in general. The model presented can easily be replicated in other African nations once the right context is set.

Acknowledgements

The authors acknowledge the UK Government funding (administered by Carbon Trust) for curriculum development under the Transforming Energy Access – Learning Partnership (TEA-LP) programme. However, the findings presented in the paper do not necessarily present the position of the UK Government.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Berry, Laurie., (2022)., A Framework for Increasing Critical Thinking, Student Engagement, and Knowledge Construction in Online Discussions (A Framework for Increasing Critical Thinking, Student Engagement, and Knowledge Construction in Online Discussions - University of Wisconsin Extended Campus (uwex.edu), accessed date: 04-04-2024)

Chikere, C.B. (2023) UniPort Entrepreneurial Centre, https://www.uniport.edu.ng/centres/770-ntrepreneurial-centre.html. Accessed 22 December 2023.

Fidanoski, F., Simeonovski, K., Kaftandzieva, T., Ranga, M., Dana, L., Davidovic, M., Ziolo, M., Sergi, B.S. (2022) The triple helix in developed countries: when knowledge meets innovation, Heliyon, Vol. 8(8).e10168. https://doi.org/10.1016/j.heliyon.2022.e10168.

Gillett, Amy. and Kelterborn, Kristin Babbie., (2022)., How to Inspire Entrepreneurial Thinking in Your Students, **Inspiring Minds** Whether or Not They're Actually Studying Entrepreneurship, February 25, 2022 (How to Inspire Entrepreneurial Thinking in Your Students | Harvard Business Publishing Education, date accessed: 10/04/2024)

Isenberg, D. (2011) The entrepreneurship ecosystem strategy as a new paradigm for economic policy: Principles for cultivating entrepreneurship, Presentation at the Institute of International and European Affairs, vol. 1(781), pp. 1–13.

Linton, Gabriel. and Klinton, Markus., (2019) University entrepreneurship education: A Design thinking approach to learning, Journal of Innovation and Entrepreneurship. Linton and Klinton Journal of Innovation and Entrepreneurship (2019) 8:3

Pailman, W., and de Groot, J. (2022) Rethinking education for SDG 7: A framework for embedding gender and critical skills in energy access masters programmes in Africa, Energy Research & Social Science, Vol. 90. 102615. https://doi.org/10.1016/j.erss.2022.102615

Sassetti, Sara., Vincenzo Cavaliere, Sara Lombardi (2022), The rhythm of effective entrepreneurs' decision-making process. The pathways of alertness scanning and search and cognitive style. A mediation model. International Entrepreneurship and Management Journal 18:555-578

Sokona, Y (2021) Building capacity for 'energy for development' in Africa: four decades and counting, Climate Policy. https://doi.org/10.1080/14693062.2020.1870915

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fostering Sustainable Future: Inter Institute Collaboration, Industry Linkage & Entrepreneurship skills in Higher education

Ale Imran1[a], Mohd Rihan2[b], Jay Prakash Singh3[c] and Vikrant Sharma4[d]

[a]Assistant Professor, Entrepreneurship Development, Zakir Husain College of Engineering & Technology, Aligarh Muslim University, India.

[b]Professor, Department of Electrical Engg., Zakir Husain College of Engineering & Technology & Coordinator-Centre for Integrated Green & Renewable Energy, Aligarh Muslim University, India.

[c]Deputy Director General, National Institute of Solar Energy, Ministry of New & Renewable Energy, Gurugram, India.

[d]Deputy Director (Tech), National Institute of Solar Energy, Ministry of New & Renewable Energy, Gurugram, India.

Abstract

The role of Green Energy in many of the Sustainable Development Goals (SDG) highlights its critical importance as a flexible, sustainable, and multi-faceted solution that adds to worldwide efforts to attain a better future. It is therefore imperative that transformative changes are incepted and incorporated in higher educational institutes of learning like Universities, Colleges, polytechnics etc., to keep up the pace with the changing landscape in the area of sustainable development. This paper presents the synergies between three important pillars i.e. Inter-institute collaboration (IIC), Industry linkages (IL), and the cultivation of entrepreneurship skills (ES) in higher education, which are quint-essential for fostering sustainable energy education. The paper also exhibits the course structure of a recently introduced Master of Technology (M. Tech) program in Green Energy and Sustainable Development, developed keeping the aforementioned key themes. The best practices incorporated in the courses structure have also been highlighted, encouraging a holistic and collaborative approach that equips students with the knowledge, skills and mindset to address the challenges of climate change and global warming.

Keywords: Sustainable Energy Education; Higher Education Institutes; Inter-Institute Collaboration; Industry Linkage; Entrepreneurship skills; Green Energy Curriculum.

How to cite: Imran, A.; Rihan, M.; Singh, J. P.; and Sharma, V.; (2024) Fostering Sustainable Future: Inter-Institute Collaboration, Industry Linkage & Entrepreneurship Skills in Higher Education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 368-377. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The increasing concerns over climatic change, environmental degradation, and the non-replenishable nature of conventional energy sources have elevated the importance of sustainable and green energy solutions. There's no doubt that in today's rapidly changing global landscape, the correlation between environmental sustainability and energy innovation holds profound importance for creating a better future. In India, these concerns are also on top priority of the government and policymakers. Because of this vision, India has; in recent years, taken large strides in adopting green and renewable sources of energy. Achieving targets of 175 GW by 2022 and 500 GW by 2030 is reflective of this mission.

As countries across the globe, wrestle with the pressing demands of climate change and the necessity of transitioning to green and sustainable energy solutions, the role of higher educational institutes becomes highly critical. Educational Institutes like Colleges and Universities can play a quintessentially important role by serving as hubs for knowledge creation, dissemination, and skill development in the area of sustainable energy. These seats of higher learning are uniquely positioned to develop innovative technologies and launch scalable spin-offs that can pave the path toward a carbon-neutral future. Through Inter-institute collaborations, Industry linkages, internships & apprenticeships, and Imparting entrepreneurial skills, academic institutes can empower students to creatively address challenges in a way that contributes to a sustainable future.

In this paper, the authors have explored the synergies between inter-institute collaboration, industry linkages, and the cultivation of entrepreneurship skills in higher education for fostering sustainable energy education. Furthermore, the course structure especially designed for Master of Technology (M.Tech) program in "Green Energy and Sustainable Development" at Faculty of Engineering & Technology, Aligarh Muslim University, India in close collaboration with National Institute of Solar Energy; in close lines with the aforementioned themes has also been presented.

The paper is organized as follows: After brief introduction in Section I, a discussion regarding the changing roles of higher educational institutes in sustainable energy education is highlighted in Section II. Section III talks about the importance of three critical pillars i.e. inter-institute collaboration, industry linkages, and the cultivation of entrepreneurship skills in higher education & how it could be decisive; whereas Section IV presents the introduced course structure and it's best practises. Section V concludes the paper.

2. Role of Higher Educational Institutes in Sustainable Energy Education

Higher educational institutes like Universities, Colleges, Polytechnics, etc. are uniquely positioned and can play a critical role in sustainable energy education by:

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Building capacity through the development of new knowledge and insights, and therefore, providing effective solutions to related problems.
- Regular supply of highly educated and skilled human resource who can develop and implement the aforementioned solutions.
- Promoting multi-disciplinary collaboration in research and innovation, besides fostering entrepreneurship skills among stakeholders entering energy sector.

However, it has been observed that there is a lag between the rapid transitions happening in green energy and the course structure or curricula of higher education institutes; particularly engineering education in India. Some of the areas which requires an urgent need to articulate a new paradigm for successful and sustainable transition to green energy, specifically in engineering education are as follows:

2.1 Research and Development

The Universities & Colleges can act as research and innovation hubs by facilitating cutting-edge research in sustainable energy technologies that are more meaningful for the present requirements of green energy. Some of the important research areas in line with the national requirements of India are:

a) Developing Solar PV modules of higher efficiency with new technology/material, new shape, with lesser effect of ambient temperature, requiring less water for cleaning etc.

b) Operation and Maintenance of solar plants and role of Artificial Intelligence, Machine Learning, Big Data etc.

c) Blockchain enabled Peer-to-Peer Energy trading

d) Grid Integration challenges and their solution strategies

e) Improvements in Battery technology storage

f) Off grid applications with and without battery storage

g) Issues related to handling of PV Waste

Furthermore, the newly evolved field of green energy and sustainable development requires combining expertise from different research and educational disciplines, that helps in creating a conducive environment for exploring and developing new ideas. The academic institutions need to establish and promote inter disciplinary, multi-disciplinary and transdisciplinary work in the area.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2.2 Training of Skilled Human Resources

- Lack of trained manpower and fresh engineering graduates in the area of solar energy has been an area of concern. It's of quintessential importance that the gap between the technical competence required in the engineers to better serve the requirements and their knowledge level, needs to be bridged. Some of the initiatives which can be of help are:

a) Short duration programs for fresh engineering graduates to make them aware of the developments, opportunities and challenges in the field.

b) Training for working engineers of distribution companies will help in moving forward towards achieving the targets of National Solar Mission. In-fact this has been one of the main reasons behind slow adoption of small rooftop solar plants in country.

c) Development of high-quality content for these training program and ensuring quality of empanelled training centres.

d) Relevant conferences, workshops and symposia dealing with green energy and sustainable development should be promoted and organised.

e) Meaningful collaboration within academic institutes and some joint programs with institutes like National Institute of Solar Energy, National Institute of Wind Energy and National Power Training Institute, needs to be initiated.

2.3 Electrical Engineering Education

Conventionally the green sources of electricity like solar, wind etc. have been considered and taught as minor components of the electric power network. In fact, the renewable nature of these sources, as compared to coal was the primary reason behind their inclusion in the curricula. However, with the changing dynamics, these sources are now set to play a more dominant role in the power network because of their 'green and sustainable' nature. It is therefore pertinent that this change should also be reflected in the engineering programs in the country. The following, therefore should form an integral part of any electrical engineering curriculum now:

a) Impact of conventional electricity generation on climate
b) Sustainable Development Goals (SDG) and role of electric energy system
c) Major transformation in electrical supply system
d) Variability challenge of solar and wind energy penetration, in inverter dominated grid
e) The role of schemes launched by Govt. for promoting Green Energy; like in India multiple schemes like Solar Park, CPSU, Solar City, Grid Connected Solar Rooftop, PM-KUSUM etc regarding which the students' needs to be apprised as well
f) Promoting entrepreneurship education and making best use of new technologies like Artificial intelligence, big data, cloud computing, Block chain etc.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.4 Academic Incubators and Accelerators

Academic incubators and accelerators play a crucial role in promoting green energy and sustainable development by providing a supportive environment for the ideation, development, and scaling of innovative solutions. They can contribute by

a) Fostering innovative ideas of stakeholders for sustainable energy solutions
b) Giving access to resources critical for development and testing of green energy technologies
c) By providing mentorship and guidance on technical, business and regulatory aspects of the green energy sector.
d) By offering seed funds to early-stage start-ups for developing Minimum viable products and seeking validation
e) Facilitating collaboration and networking opportunities between start-ups, industry stakeholders and governmental agencies, thereby creating a dynamic ecosystem
f) Organizing pitch sessions and connects with Angel Investors, Venture Capitalists, etc.

Furthermore, besides the aforementioned; working out how to address behavioural change and adaption is also critical for better adoption of green energy. The bigger picture of climate crisis has to be conveyed to the people to get their full cooperation and academic institutes can play a key role in creating awareness and by taking the idea of Green Energy & Sustainable Development "beyond engineering colleges". School level students also needs to be motivated and informed about the climate crisis, need for sustainable development and importance of adoption of green energy. These students can then serve as the 'brand ambassadors' of green energy and imbibe the responsibility towards the idea of sustainability from a very early stage.

3. Focus on Inter-Institute Collaboration, Industry-linkage and Entrepreneurship skills in NEP-2020

The National Education Policy (NEP) 2020 of India is a comprehensive document that outlines the vision and framework for transforming the country's education system. It envisions a learner-centric, inclusive and flexible education system that prepares students for the challenges of the coming years. Among the various laid progressive reforms, it also focusses on several aspects related to inter-institute collaboration, industry connectivity, and the imparting of entrepreneurship skills in higher education.

Inter-institute collaboration in the area of Green Energy and Sustainable Development brings several benefits contributing to the advancement of research, technology development, and the overall sustainability agenda. The collaboration allows pooling of the human resource expertise from different specializations and sharing of the research facilities. It is particularly

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

beneficial for students who get an exposure to a wider range of expertise and gain access to diverse perspectives, contributing to a more comprehensive education in green energy. Moreover, the holistic approach that is quintessential for the overall idea of sustainable development can benefit immensely from a multi-disciplinary and cross-disciplinary approach which could be achieved through Inter-Institute collaborations. In fact, it also enhances the international visibility of participating institutions, who can mutually benefit by joint publications and research projects.

Industry Linkage is another strategic approach to tackle complex problems and foster the need for sustainable development. The linkage helps the academia to align their curriculums with the industry needs and helps the upcoming professionals to be industry-ready. Having good linkages with the industry is also helpful for providing internship and apprenticeship opportunities to students in accordance with the market needs, which prepares them for a career in green energy and sustainability.

Developing *entrepreneurship skills* among the students is another area that requires attention. Entrepreneurship education helps students develop the acumen to identify problems and propose solutions to complex issues affecting the uptake of green energy and sustainable development. It also helps students translate their ideas into real-life ventures, that can achieve product-market fit and later transform the same to business model-market fit in the growth stages of start-up. Moreover, the role of future entrepreneurs in creating an impact on local communities can't be denied. They can bring clean and green energy solutions to underserved areas, resulting in a contribution to improving living conditions and sustainable development. Table 1, shows the cross mapping between the requires areas of attention in higher education institutes & the critical importance of Inter-institute collaboration, Industry linkage and Imparting entrepreneurship skills. The table clearly delineates how different sectors of higher education contribute to, and benefit from these three key themes, creating a structured approach for enhancing the educational outcomes related to sustainable energy and development.

Table 1 : Cross mapping table depicting the importance of IIC, IL & Entrepreneurship skills

Role of Higher Education Institutes: → → → → *Usefulness of the following*: ↓ ↓ ↓	**Research & Development**	**Training of Skilled Human-resource**	**Electrical Engineering Education**	**Academic Incubators**
Inter-Institute Collaboration	2.1(a) to 2.1(g)	2.2 (b), 2.2 (c), 2.2(d) & 2.2 (e)	2.3(b)	2.4(a)& 2.4(b)
Industry Linkage	2.1(a),2.2(e) 2.2(f) & 2.2(g)	2.2(a) & 2.2 (d)	2.3(g)	2.4(b),2.4(d) & 2.4(e)
Imparting Entrepreneurship Skills			2.3(e) &2.3(f)	2.4(c)

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. "Green Energy & Sustainable Development" -A recently Introduced Master's level program at AMU, India

Some of the well-known universities across the globe have taken the lead in introducing courses aligned with the domain of sustainable development and green energy. Stanford University (USA), University of California Berkeley (USA), Delft University of Technology (Netherlands), Technical University of Munich (Germany), National University of Singapore (Singapore), University of New South Wales (Australia), etc., are examples of few of those universities that have offered comprehensive programs at different levels to the students.

Aligarh Muslim University (AMU), India has recently introduced in 2023, a Master's level program (M. Tech) in Green Energy and Sustainable Development, under the Centre for Integrated Green & Renewable Energy, Faculty of Engineering & Technology in close collaboration with National Institute of Solar Energy (NISE), India. AMU is one of the oldest central universities in India, having completed its centenary year in 2020 ; is consistently ranked among top 10 universities in India & is currently accredited by National Assessment and Accreditation Council (NAAC) with CGPA of 3.35 on Four Point Scale at "A+" Grade. Furthermore AMU boasts of one of largest non-commercial installations of Renewable Energy in India, having a total capacity of 6.5 MWp. Among all the educational institutions in the country this is probably the largest installation at present. The plant together (ground mounted & rooftop) is generating about 27,000 units of electricity per day leading to equivalent saving of 20,000 kg CO_2 emissions per day. These projects have, therefore, contributed in a major way towards Clean Energy. NISE, on the other hand is an autonomous institute, under Ministry of New & Renewable Energy (MNRE), Govt. of India focusing on research and development, solar component testing and certification, capacity building, and development of solar products and applications.

The idea was to introduce a specialized course in Green Energy that takes into consideration the importance of theoretical foundation, along with the practical acumen required to navigate the rapidly evolving sustainable energy sector. The course goes beyond the traditional boundaries and places the three critical components of Inter-Institute Collaboration, Industry Linkage & imparting Entrepreneurship skills at the heart of learning experience for the students. The course not only provides the requisite technical knowledge and exposure to the latest advancements in the area of green energy but also lays emphasis on developing student's entrepreneurial skills, which is integral to empowering the next generation of visionaries and leaders. The course structure of the recently introduced M. Tech program in Green Energy & Sustainable Development is shown in Table II. Some of the good practises of the course worth mentioning are as follows:

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Table II : COURSE STRUCTURE for M.TECH (Green Energy & Sustainable Development)

SEMESTER-I			**SEMESTER-II**	
Course Category	**Course Title**		**Course Category**	**Course Title**
ES	Solar Energy for Sustainable Development		PC	Schemes, Policies & Regulations On Green Energy
PE	Renewable Energy Engineering		PE	Seminar-I
PC	Energy Efficiency, Conservation And Audit		PC	Project-II
PC	Laboratory		The entire II Semester for the students Of M.Tech (Green Energy & Sustainable Development) is held at National Institute of Solar Energy	
PC	Green Energy Entrepreneurship			
PC	Project			
	TOTAL CREDITS = 24		**TOTAL CREDITS = 12**	
SEMESTER-III			**SEMESTER-IV**	
OE	Open Elective		PC	Pre-Dissertation Seminar
PC	Dissertation (Phase-I)		PC	Dissertation (Phase-II)
PE	Seminar-II			
PE	Industry Internship			
	TOTAL CREDITS = 18			**TOTAL CREDITS = 18**
where ES-Engineering Science, PC-Program Core, PE-Program Elective, OE-open elective				

Source: Own elaboration

a) The program fells in sync with the national requirements for green energy transition and the National Education Policy 2020
b) Students study their first semester at AMU, followed by the second semester at NISE making it a unique collaborative programme on Green Energy in the country. This program is in line with the theme of the Education Working Group of G-20.
c) Availability of such a large-scale Grid Connected installation in the university has provided a very good test bed for the enrolled students in the course to address different issues pertaining to integration of renewable energy with the grid
d) During the second semester, the students are taught regarding the latest schemes, policies and regulations on Green Energy and exposed to the latest state of the art laboratories and facilities at NISE, Gurugram. They are given practical exposure to Battery testing facilities, measuring and characterization of solar cells, solar inverters, solar water pumps, outdoor PV module characterization etc. They are also required to complete a project component, which helps them in developing research acumen
e) Industry linkage is another aspect that has been focussed upon during the design of the course structure. Industry Internship has been made mandatory and has been

(cc) BY-NC-SA 2024, Editorial Universitat Politècnica de València

assigned 04 credits, across III semester. The students currently enrolled in the I batch of the program have completed their internships/apprenticeships in companies like Holmium Technologies, O2 Power, Intecco Technical Services, Anmol Solar Pvt Ltd, TERI etc. Regular insights by industry experts, shared through guest lectures, invited talks, visits, networking opportunities etc is another regular feature of the course.

f) Course on Green Energy Entrepreneurship, offered to the students in First semester is a core component of the course structure. The course holds significant value in today's scenario and the role technocrats need to play by creating products or services which are able to help the shift towards sustainability. The course focusses on cultivating entrepreneurial mindset, opportunity and problem identification, proposing creative solutions using Design thinking approach, crafting useful value propositions & innovative B-Models, challenges encountered by the Green Energy entrepreneurs, current trends in solar energy entrepreneurship, Emerging financial models for rooftop solar sector etc for widespread reach of green energy solutions.

5. Conclusion

Integration of Inter-Institute Collaboration (IIC), Industry Linkages (IL), and Entrepreneurship Skills (ES) within higher education frameworks, notably enhances the educational approach towards sustainable energy and development. The implementation of M.Tech program in Green Energy and Sustainable Development exemplifies a forward-thinking model that empowers students to be proactive in addressing the challenges posed by climate change. It is believed that upon completion of the program, the students would be having a holistic understanding and application of green technologies, promoting a culture of sustainability that extends beyond academic boundaries into real-world applications.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Farinha, C., Caeiro, S., & Azeiteiro, U. (2019). Sustainability strategies in Portuguese higher education institutions: Commitments and practices from internal insights. *Sustainability*, 11(11), 3227. https://doi.org/10.3390/su11113227

Mohammad Rihan, "Green Energy Transition in India- Including the Success Story of AMU", *Publication Division AMU*, ISBN: 9789380510477O2

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fuertes-Camacho, M.; Graell-Martin, M.; Fuentes-Loss, M.; Balaguer-Fábregas, M. (2019) Integrating Sustainability into Higher Education Curricula through the Project Method, a Global Learning Strategy. *Sustainability* 2019, 11, 767

Amaral, L. P., Martins, N., & Gouveia, J. B. (2015). Quest for a sustainable university: A review. *International Journal of Sustainability in Higher Education*, 16(2), 155–172. https://doi.org/10.1108/IJSHE-02-2013-001

Mohammad Rihan, Tariq Mansoor (IWGM 2021), Decarbonising the Aligarh Muslim University Campus: An Experiential Analysis of Initiatives, their Impact and Lessons Learned , *Proc. 7th International (Virtual) Workshop on UI Green Metric World University Rankings*

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Guiding Policy Communication: Tailoring Energy Education to Diverse Public Sentiments

Christina Speck[a], Philipp Fritz[a], Christof Weinhardt[a] and Jonas Fegert[b]

[a]Karlsruhe Institute of Technology, Germany
[b]FZI Research Center for Information Technology, Germany

Abstract

Existing research has manifested the significant role of public sentiments in the effectiveness of energy policies. However, there is a discernible gap in how these sentiments are addressed in policy design. Traditional policy approaches often rely on a generalized, one-size-fits-all methodology, neglecting the varied impacts on different demographics and communities. This results in a limited and often polarized representation of public sentiments, particularly in online social networks. Our research seeks to fill this gap by focusing on the design of education programs, as part of energy policies, through sentiment based tailored energy education, recognizing the need for a more nuanced and inclusive approach that resonates with diverse audience groups.

Therefore, this study examines the integration of public sentiments on the energy and climate crises into energy education, utilizing data from a weekly panel study on energy and climate sentiments, with a focus on Germany. Our methodology merges quantitative panel data analysis with qualitative insights from an interactive workshop with policy experts, aiming to inform energy education. For further research, we sought insights from the interactive workshop to gather requirements for an educational dashboard aimed at policymakers. The goal of the overarching study is to improve understanding of diverse group sentiments on energy transition, ultimately enhancing policy relevance and effectiveness. Preliminary findings from these sessions provide essential feedback on policymakers' needs for data representation, informing the development of a real-time public sentiment dashboard.

Keywords: sentiment analysis; policy communication; energy crisis; tailored education.

How to cite: Speck, C.; Fritz, P.; Weinhardt, C. and Fegert, J. (2024) Guiding Policy Communication: Tailoring Energy Education to Diverse Public Sentiments. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 378-386. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Many studies have underscored the influence of public attitudes and beliefs about climate change risks on their engagement and support for climate change adaptation and mitigation strategies (Liu et al., 2022; Wang et al., 2023). A pivotal strategy is the transition to renewable energy, which necessitates significant techno-economic transformations, potentially straining public support due to factors like increased electricity costs and additional land use (Huh et al., 2015). Therefore, the success of political initiatives for a socially equitable energy transition is deeply intertwined with public advocacy (Li et al., 2019).

In regards to public advocacy, a critical gap exists in the current approach to policy design: policies often adopt a one-size-fits-all methodology, failing to account for the diverse impacts these policies have on different localities and individuals (Grossmann, 2019). This leads to a spectrum of public sentiments regarding changes in renewable energy related policies, hereafter refered to as energy policies, which are often overlooked as many studies tend to view public sentiments as a homogeneous entity (Liu et al., 2022). Additionally, public sentiments towards the transition to renewable energy is often depicted through social network sentiments (Li et al., 2019). The amplification of polarization on these critical issues, especially evident in the realms of online social networks (OSN), raises concerns about the accuracy of these networks as a representation of the actual sentiments within the population.

Efforts in tailoring energy policies to specific income groups already present a willingness of policymakers to break out of the one-size-fits-all methodology. However, low take-up rates of energy assistance programs (Chlonde et al., 2022) show that targeted policies do not necessarily translate into policy success. Moreover, for energy policy success, especially on municipal level, policies in form of incentives or regulations need to be accompanied by education programms (Azevedo et al., 2013). Understanding the varied sentiments across different demographic and socio-economic groups could therefore help to achieve targeted energy education and, ultimately, reach robust public support for energy policies (García-García, 2023). Thus, our research question evolves: *How can we harness diverse public sentiments to enhance energy policy in its energy education, ensuring effective energy policies' conveyance for various audiences?*

As a pilot study, our paper explores how public sentiments regarding the energy and climate crises can be integrated into the communication of energy policies. We utilize data from a bi-weekly panel study focused on energy and climate sentiments in Germany. Additionally, we engage with policy experts in an interactive workshop to gather requirements for the future development of a dashboard tailored for policymakers. This tool aims to enhance policymakers' understanding of diverse public sentiments related to the energy transition, thereby helping to increase the relevance and effectiveness of policies through energy

BY-NC-SA 2024, Editorial Universitat Politècnica de València

education. The initial findings from these workshops offer insights into policymakers' data representation needs, guiding the development of a dashboard that provides bi-weekly insights into public sentiments on energy and climate crises.

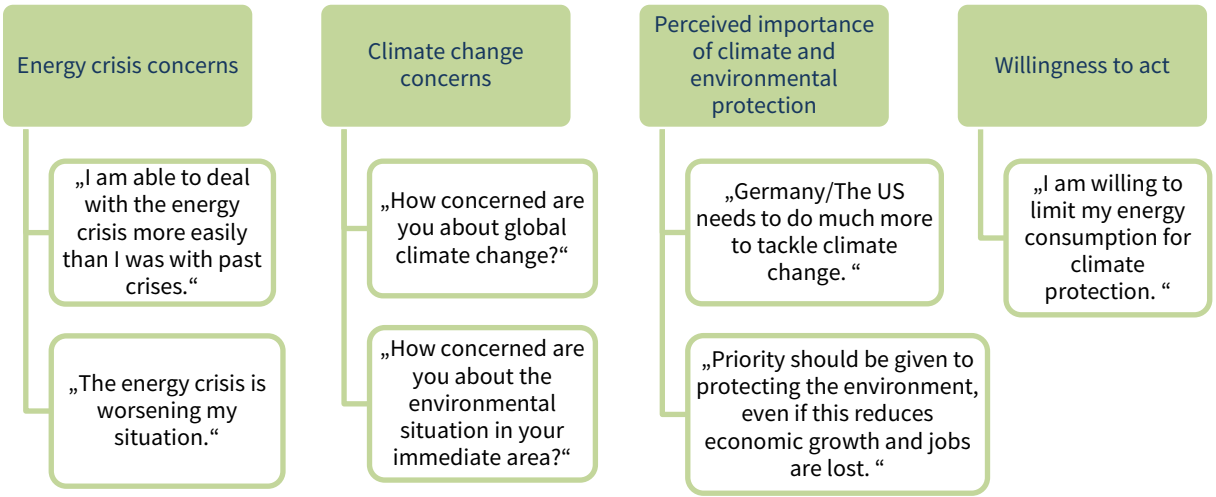
2. Methods

This work uses a structured process to taylor energy education to heterogenous groups, based on their sentiments towards energy and climate crises, which consists of four steps: (1) data collection, (2) identification of heterogenous groups within the data, (3) analysis of groups to determine suitable topics of energy education as well as communication channels, (4) evaluation through an interactive workshop with policy experts.

2.1 Data Collection

The database for our analysis is a panel study on social sentiments. The aim of this study is to investigate the extent to which events, actions, and communication measures influence social sentiment in the wake of a current crisis (e.g., the energy crisis, the climate crisis). The project intends to use the experience sampling method from psychology (Hektner et al., 2007) with a bi-weekly representative panel to continuously inquire about sentiment – simply and accessibly through a web application that poses the same questionnaire (starting November 2022) to study participants. Conclusions should be drawn from a comparison of the answers with events in time, based on participant's changing social sentiment responses. Questions on demographics as well as trust in institutions, media consumption, and political orientation allow for identifying differences in various social groups.

Fig. 1 – Energy- and climate-related questions in the panel study



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

Within this study, 4.500 participants – 1.500 in Germany and 3.000 in the USA – are subjected to the bi-weekly questionnaire. Previous work suggests that sentiments on climate change and advocacy for climate change mitigation strategies, such as energy-related policy, are correlated (Liu et al., 2022) as well as pre-studies on this dataset suggest. Therefore, we focus our analysis on climate related questions (i.e., climate change concerns, perceived importance of climate and environmental protection) and energy related questions (i.e., energy crisis concerns, willingness to act), as shown in *Figure 1*, answered on a Likert Scale.

2.2 Identification of Heterogenous Groups

To participants' answers on the questions described in *Figure 1*, we carry out a k-means cluster analysis for one week of data. We focus our analysis on one week's data as a snapshot of the data collection at the time. To determine the optimal number of clusters, we use the number of clusters corresponding to the first non-linear inflection point when plotting the within-cluster sums-of-squares in order of size, also employed in (Liu et al., 2022). Further, we employ the silhouette method to validate consistency within the clusters (Rousseeuw, 1987). As a result, we obtain four clusters within the German panel data. This clustering allows us to categorize respondents into heterogenous groups based on similar sentiments, providing a nuanced understanding of diverse perspectives within the German and U.S. populations.

2.3 Group Analysis

The diverse perspectives of each group inform about the needs in energy education, giving us indications on the topics of education. We further explore the characteristics of each cluster by analyzing participants' media consumption habits. Thereby, we determine suitable communication strategies.

2.4 Evaluation through an Interactive Workshop with Policy Experts

To refine our insights, a workshop is conducted with a group of policy experts of a responsible Federal Ministry in Germany, where we present our analysis results. The workshop is structured in (a) a pre-workshop Q&A on participants' current knowledge and topics of interest, (b) cluster analysis presentation, (c) interactive group discussions to brainstorm further questions of interest, (d) reflection session on how participants plan to apply these insights.

3. Preliminary Results

3.1 Dataset Description

Our analysis focuses on the German population, as for the scope of this paper, only German policy experts were asked to participate at our interactive workshop. The German clustering dataset of one week's panel data included 1590 participants, with 53% males and 47%

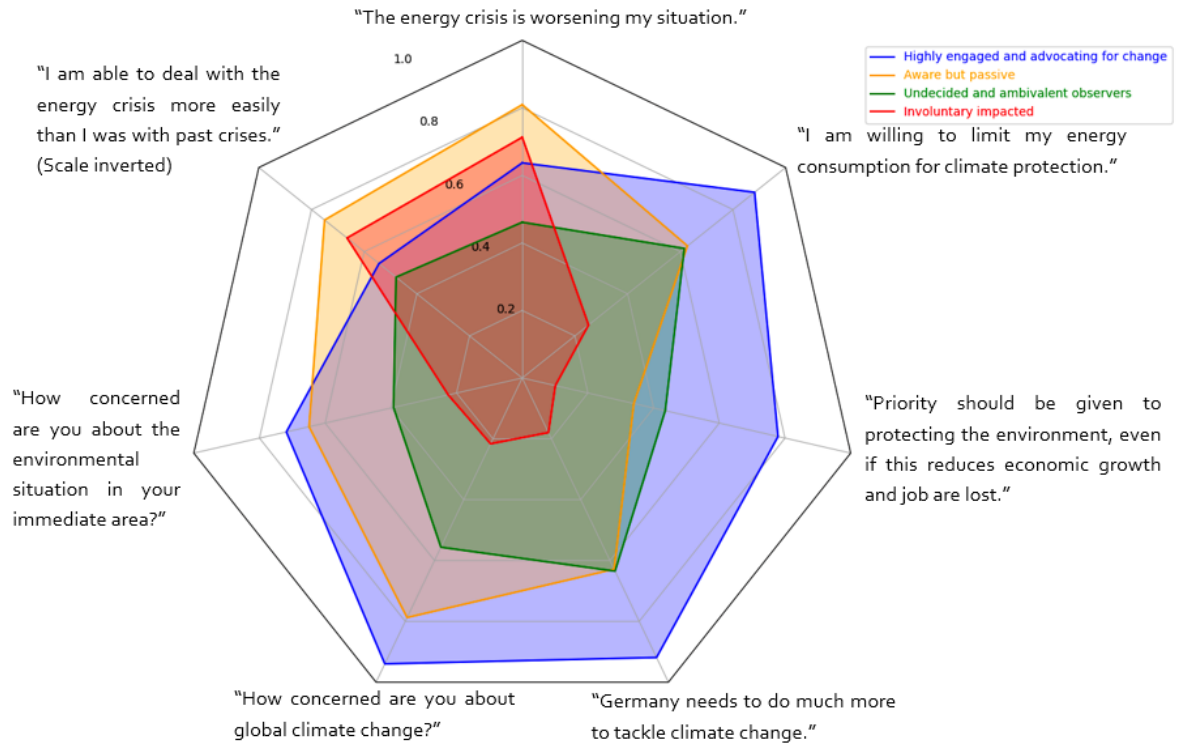
BY-NC-SA 2024, Editorial Universitat Politècnica de València

females and an average age of 49 years. The mean household income for the sample fell within the range of €2200-€2600.

3.2 Heterogenous Group Description

From the k-means clustering approach described in *Section 2.2*, we could identify four clusters with a size ranging from 14-33 of the sample. In *Figure 2*, the clusters are visually represented through their averaged answers to the questions presented in *Figure 1*.

Fig. 2 – Average results for all energy and climate questions per cluster (0 = Completely disagree/Not concerned at all - 1 = Completely agree/Very concerned)



Source: Own elaboration

In *Table 1*, we describe the profiles of each cluster according to the clustering variables and their demographic characteristics in more detail, aligning with the profiling approach by Hall et al. (2021).

 BY-NC-SA

Table 1 – Summary profiles of each cluster based on answers from the panel questionnaire

	Summary Profile
Highly engaged and advocating for change (33%)	• These individuals are deeply concerned about both global and local climate change. They believe the government should intensify efforts in climate protection, prioritize environmental conservation over economic growth and job security, and are willing to reduce energy consumption to address climate change. • Compared to other clusters, they express the highest concern for climate change and strongly support climate protection measures. However, opinions within this cluster vary regarding the impact of the energy crisis on their situation. • They have the tendency to be older and to be childless. They have a high level of education, are employed in middle or high-level jobs, and are in education or retired. They live in one or two-person households and have an average household income within the cluster data.
Undecided and ambivalent observers (29%)	• People in this cluster are mostly undecided when it comes to concerns about climate change, the energy crisis or their willingness to support public or individual climate protection measures. • They are the oldest with an average of 61 years and have the tendency to be male, childless and living in a two-person household. They have the highest number of retired people and the highest household income.
Aware but passive (24%)	• Concerned about local and global climate change, this group is severely impacted by the energy crisis, finding it more challenging than other crises. However, they do not prioritize environmental protection over jobs and are undecided as to whether the state must do more to combat climate change or whether they are willing to reduce their energy use to do so. • Tendency to be female, middle-aged, intermediate school education, low household income, married or divorced with one or two children.
Involuntary impacted (14%)	• People in this cluster are not concerned about climate change but experience a significant deterioration in their situation due to the energy crisis, struggling to cope with its challenges. They do not believe that Germany needs to intensify efforts to combat climate change and are unwilling to reduce their energy consumption for climate protection. They reject the idea of prioritizing environmental protection over jobs. • They have the tendency to be male, middle-aged, married and to have children. They tend to work in full-time jobs in offices on the middle-management level or in technical or craft professions with an average household income within the cluster data.

Source: Own elaboration

3.3 Group Analysis Results

We focus on the "undecided and ambivalent observers", as being the group least concerned about the energy crisis, shown in *Figure 2*. By analyzing their answers to energy-related questions, we gain valuable insights shaping a possible educational strategy. Further, we

BY-NC-SA 2024, Editorial Universitat Politècnica de València

observe the possible accessibility of people in this cluster, defined through their trust in institutions and media consumption habits. The aim is to effectively engage them on energy-related issues, as they are a group with moderate willingness to act, as shown in *Figure 2*. Therefore, they could benefit from educational content highlighting the crucial role of households in the expansion of renewable energies.

Participants indicated their trust in different media types using a 5-point Likert scale (1 = A lot of trust to 5 = No trust at all) and the frequency of their media use. Notably, the "undecided and ambivalent observers" express high trust in public television, press, newspapers and classic news sites on the internet (all averages around 2.5), while having least trust in social media (4.0 in average), aligning with their media usage behaviour. They get news from public media institutions 3-4 times a week and from alternative source as social media only 1-2 times a month. Overall, the "undecided and ambivalent observers" display significantly higher media usage levels compared to other clusters.

3.4 Interactive Workshop Results

The interactive workshop took place with eight participants in November 2023. One general response, in which all participants agreed, was the complementing methodology of clustering surveys by relevant questions, in addition to the common clustering approach by demographics. This way assumptions made by demographic clustering don't result in common biases. Moreover, clustering into groups of common sentiments towards the energy crisis enables well-founded and targeted education strategies towards these energy-related conceptions per heterogenous group.

Further, a significant insight was the necessity of long-term observations in our data visualisation. Tracking changes in public opinion over time is crucial for assessing the impact of policy interventions (e.g., with energy education) and adapting to evolving societal engagement with renewable energy issues. However, the workshop emphasized the importance of local discourse, particularly through an East-West and urban-rural setting comparative analysis for the German sample, to understand regional differences in attitudes and tailor policies, especially in educational programms accordingly. Moreover, participants stated the need for easily integrating external data points to enrich sentiment data with further data such as OSN data like Telegram.

4. Outlook

We contributed to a first understanding of different sentiments, especially concerning the energy crisis. We identified a key demographic, the "undecided and ambivalent observers," who are notably least concerned of the energy crisis and, therefore, do not see high needs for change. This group's current observer role raises potential for engagement through energy

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

education. Additionally, our analysis revealed a general low trust in media across populations, suggesting an urgent need for innovative communication strategies in energy policy dissemination. Further, the feedback from the interactive workshop underscores the necessity of a tool in aiding policymakers to make informed decisions, based on public sentiment, and educate for policy conveyance.

Our research proposes a method to harness diverse public sentiments towards energy-related issues for more tailored policies in the form of energy education. Our approach emphasizes the need for policymakers to be well-versed in societal sentiments, ensuring that policies are not only well-informed but also inclusive and reflective of public sentiment.

However, the reliance on feedback from a single federal ministry may not fully capture the diverse perspectives necessary for a comprehensive need in public sentiment data for policy design. Additionally, our analysis currently lacks a long-term perspective on sentiment changes, particularly in response to specific energy legislation. This limitation points to the need for a more longitudinal approach in future research.

Looking ahead, this would enable a more detailed analysis of how public opinion evolves over time and in response to policy changes. Moreover, the methodology and communication strategies developed for the German context could be adapted and applied to data from the United States, offering a comparative perspective and potentially revealing unique insights into different societal responses to energy policies. Such cross-cultural analysis could enrich our understanding of global public sentiment towards energy issues.

In conclusion, our study lays the groundwork for more targeted and effective energy education, tailored to the nuanced needs and perspectives of diverse societal groups. By continuing to develop tools and strategies that capture and respond to these sentiments, we can contribute to a more sustainable and inclusive approach to energy policy and education.

Acknowledgements

We express our sincere gratitude to the Alfred Landecker Foundation for their generous funding of our research project "Social Sentiment in Times of Crises."

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Azevedo, I., Delarue, E., & Meeus, L. (2013). Mobilizing cities towards a low-carbon future: Tambourines, carrots and sticks. Energy policy, 61, 894-900.

Chlond, B., Goeschl, T., & Kesternich, M. (2022). More money or better procedures? Evidence from an energy efficiency assistance program.

García-García, P. (2023). Profiles and categorisation of perceptions and attitudes among European citizens regarding the just energy transition. *RIPS: Revista de Investigaciones Políticas y Sociológicas*, 22(1).

Grossmann, K. (2019). Using conflicts to uncover injustices in energy transitions: The case of social impacts of energy efficiency policies in the housing sector in Germany. *Global Transitions*, 1, 148-156.

Hall, S., Anable, J., Hardy, J., Workman, M., Mazur, C., & Matthews, Y. (2021). Matching consumer segments to innovative utility business models. *Nature Energy*, 6(4), 349-361.

Hargreaves, T., & Middlemiss, L. (2020). The importance of social relations in shaping energy demand. *Nature Energy*, 5(3), 195-201.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). Experience sampling method: Measuring the quality of everyday life. *Sage*.

Huh, S. Y., Woo, J., Lim, S., Lee, Y. G., & Kim, C. S. (2015). What do customers want from improved residential electricity services? Evidence from a choice experiment. *Energy Policy*, 85, 410-420.

Labanca, N., & Bertoldi, P. (2018). Beyond energy efficiency and individual behaviours: policy insights from social practice theories. *Energy Policy*, 115, 494-502.

Li, R., Crowe, J., Leifer, D., Zou, L., & Schoof, J. (2019). Beyond big data: Social media challenges and opportunities for understanding social perception of energy. *Energy Research & Social Science*, 56, 101217.

Liu, T., Shryane, N., & Elliot, M. (2022). Attitudes to climate change risk: classification of and transitions in the UK population between 2012 and 2020. *Humanities and Social Sciences Communications*, 9(1), 1-15.

Loock, M. (2020). Unlocking the value of digitalization for the European energy transition: A typology of innovative business models. *Energy research & social science*, 69, 101740.

Rousseeuw, P. J. (1987). Silhouettes: a graphical aid to the interpretation and validation of cluster analysis. *Journal of computational and applied mathematics*, 20, 53-65.

Wang, S., Höhler, J., Ang, F., & Lansink, A. O. (2023). Dutch dairy farmers' adoption of climate mitigation measures–The role of socio-psychological and socio-demographical factors. *Journal of Cleaner Production*, 427, 139187.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Crossing Boundaries in Sustainable Energy Education: Transnational Learning is a Two-way Street

Lenny van Onselen[a], Evelien Ketelaar[b] , Angelique Ruiter[a], Esther Wijma[b], and Martijn Rietbergen[c]

[a]Research group Co-design, HU University of Applied Sciences, The Netherlands
[b]Research group Vocational Education, HU University of Applied Sciences, The Netherlands
[c]CoE Smart Sustainable Cities, HU University of Applied Sciences, The Netherlands

Abstract

In so-called centres of vocational excellence (CoVE), five European regions aim to improve sustainable energy education in their regions collaborating in a four-year project. A CoVE is a regional ecosystem where institutions of vocational and higher education, companies, and other organisations work together on education, innovation, and research in a rapidly developing field, which, in this case, is sustainable energy education. This paper describes a first analysis of regional and transnational learning that takes place within and across the five regions. The boundary-crossing theory (Akkerman & Bakker, 2011) is used as a lens to reflect on learning within regions and across borders. The authors identified three themes in a preliminary analysis of the data: inter-CoVE learning, valuable learning experiences, and participation. Inter-CoVE learning is a two-way street between transnational and regional meetings and occurs through sharing expertise and knowledge. Transnational learning is about learning new ways of working and teaching practices to strengthen CoVEs. A key enabler in learning within regions and across borders is presence and commitment on an individual and group level.

Keywords: regional learning; transnational learning; boundary crossing; collaboration

How to cite: van Onselena, L; Ketelaar, E; Ruiter, A.; Wijma, E. and Rietbergen, M. (2024) Crossing Boundaries in Sustainable Energy Education: Transnational Learning is a Two-way Street. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 387-394. https://doi.org/10.4995/2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Europe urgently needs skilled professionals for the energy transition (van de Plas et al., 2022). Vocational education needs to be adjusted to the skills needed for this energy transition and improved to educate professionals with the required skills. Learning on this matter across Europe and within local ecosystems seems a promising way forward. However, little is known about how regional and transnational learning interact with each other (Mierlo *et al,* 2020). What is known, is that transnational and regional learning is a challenge, as each region and organisation has its own set of practices, governance and (learning)culture (Keay *et al.,* 2017*)*.

Learning across organisational and international boundaries may lead to tensions in collaboration (Oonk *et al.,* 2021). Boundary crossing competency is a way to find solutions, using the learning that takes place at these boundaries (Akkerman & Bakker, 2011). According to Akkerman and Bakker (2011) the literature identifies four potential learning mechanisms that occur across boundaries:

1. Identification: The process of becoming aware of one's own beliefs and identity and how they might differ the way others see the world
2. Coordination: Finding ways to collaborate in a productive way
3. Reflection: Trying to see reality, and one's own practice, through someone else's perspective
4. Transformation: Changing a way of working or action by bringing together (elements of) the different perspectives so that it becomes a new practice

This article proposes a case study on regional and transnational learning in an international project which aims to develop ecosystems for sustainable energy education. We explore how regional and transnational learning link with the theory of boundary crossing in the European project CoVE SEED.

2. Case CoVE SEED

CoVE SEED is an international collaboration of five regions in Europe: Western Macedonia (Greece), Valencia (Spain), Bochum (Germany), Turku (Finland) and Utrecht (The Netherlands). These five regions collaborate in the Erasmus+ programme to develop sustainable energy education for the energy transition through regional Centres of Vocational Excellence (CoVE). A CoVE refers to a regional network of partners that *"develop local 'skills ecosystems' to provide high-quality vocational skills to young people and adults, and contribute to regional development, innovation, industrial clusters, smart specialisation strategies and social inclusion."* (EC, 2024). CoVE SEED's objective is to build strong regional ecosystems and facilitate both regional learning and transnational learning in the quickly changing field of sustainable energy education. Each region works on founding, developing or innovating its CoVE. Within the CoVE SEED project, the five regions exchange and develop

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

knowledge, tools and ways of working. For example, good practices are shared and transferred between regions, and a shared understanding of the necessary skills for the sustainable energy sector is developed. Exchange within and between regions occurs in the frequent regional and (online and offline) transnational meetings. These meetings offer opportunities for regional and transnational learning.

3. Methodology

The case study consists of an analysis of documents created during the first 1,5 years of the project. Within the CoVE SEED project various types of meetings are being held (Table 1). Different participants contribute to the CoVEs in the SEED project: (1) SEED partners (a consortium of vocational and higher education, companies, and other organisations), some with specific project roles (e.g. project manager and work package leader), (2) regional partners (SEED partners and other organisations in a regional CoVE) and (3) regional stakeholders (national influential partners and education providers outside the consortium).

Table 1 – Overview of types of meetings in the CoVE SEED project

Meeting type	Frequency	Participants	Aim
Live transnational project meetings	Biannually	SEED partners	Communicating main project results, developing strategy, transnational collaboration, and learning together.
Impromptu project meetings	Two times	SEED partners	Exchanging project results and additional information regarding project tasks.
Work package meetings	Monthly online	Work package leaders	Coordinating work package tasks and exchanging insights from the work packages.
Project management meetings	Monthly online	Project managers and work package leaders from one work package	Coordinating a coherent delivery of main project outputs and exchanging insights and ideas for transnational meetings.
Regional project meetings	Three times a year or more	Regional partners	Making regional project progress, applying new practices from transnational meetings and work packages, exchanging knowledge, and activating new partnerships and collaborations.
Live regional stakeholder meetings	Biannually	Regional partners and stakeholders	Disseminating project results, involving stakeholders in project activities, and initiating or strengthening partnerships.

Source: Own elaboration

First, from 30 minutes of regional meetings of the five CoVEs, we retrieved fragments with factual descriptions that relate to learning during regional meetings. Second, we derived fragments from the reports of the first three transnational face-to-face meetings describing learning during transnational meetings. The notes and fragments from the documents

BY-NC-SA 2024, Editorial Universitat Politècnica de València

containing references to learning were placed in two spreadsheets: one for the regional meetings and one for the transnational meetings. The notes and quotes containing similar content were grouped, leading to three overarching themes emerging from the data.

The document analysis was enriched with examples of regional and transnational learning collected from representatives of the five regions. They were requested to send examples via e-mail of what they learned during international meetings and what they applied in the regional meetings or vice versa.

4. Results

From the document analysis and participants' reflections, we identified three themes: inter-CoVE learning, valuable learning experiences, and participation as a key issue in transnational learning.

4.1 Inter-CoVE learning

We found 11 fragments related to inter-CoVE learning in the minutes of regional meetings and 18 fragments in the reports of the transnational meetings. Inter-CoVE learning is a two-way street between transnational and regional meetings and occurs through sharing expertise and knowledge. These are examples of coordination and reflection in terms of learning from boundary crossing. The regional meetings provided the tools, infrastructure, and communication pathways needed to come to a shared understanding of, for example, best practices and skills (coordination). Furthermore, the regional meetings provided a space for partners to reflect with regional stakeholders on the exchange that occurred during transnational meetings. This allowed partners to identify what was missing in the regional practices, and what could be improved practices (reflection.)

On the one hand, transnational meetings generated inter-CoVE learning when SEED partners exchanged good practices and ways of working. A partner shared how the methodologies learned during the transnational meetings were applied in the regional meetings:

> *"We learned different workshop methodologies that were included in the maturity assessment workshop in our region."*
> *An example shared via e-mail*

Knowledge and methods were shared after the transnational meeting in the regional meetings through presentations, sharing key learning points, and explaining methods introduced, such as the project approach, a quick scan to measure CoVE maturity, and the codesign approach. Additionally, suggestions were made for adapting the CoVE, such as suggesting a new partnership or organising a stakeholder meeting.

2024, Editorial Universitat Politècnica de València BY-NC-SA

On the other hand, inter-CoVE learning occurred when the SEED partners exchanged insights from regional meetings during transnational meetings. Online meetings, workshops, and presentations of good practices were ways to exchange regional experiences.

> *"During the transnational meeting in Bochum we shared our insights regarding stakeholders engagement and conversation management."*
> *An example shared via e-mail*

Inter-cove learning can be seen as an ongoing process that led to a transformation in working in the CoVEs. Transformation is the aim of a CoVE: to change existing practices in the regions in favour of new or in-between practices (Akkerman and Bakker, 2011). Inter-cove learning is a means to change teaching practices, improve collaboration in CoVEs, and stimulate transnational learning.

4.2 Valuable learning experiences

In the regional meetings, we found nine fragments of learning experiences about skills, good practices, and new methods learned during transnational meetings. Other learning experiences were related to ways to improve practices in the five CoVEs.Coordination and reflection learning principles, as described in boundary crossing, took place here. In addition, we observed that in some CoVEs, transformation occurred as a learning mechanism as they started to adopt and change existing practices.

The regional meetings minutes, show how the lessons learned from transnational meetings were adopted over time for local application. For example, one of the regions explicitly used the knowledge and tools they gained from a transnational workshop on codesign. In several meetings after the workshop, the codesign methodology was discussed, and notes were made on how to apply the codesing approach to ways of working in the region. In regional meeting five, the regional partners discussed the co-design workshop to further study the approach which resulted in finding the double diamond from the Design Council. In meeting six, the regional partners discussed the codesign methodology in more detail. Finally, the notes of meeting seven showed how the codesign methodology was used for a workshop for the stakeholder meeting:

> *"... the partners finalized the meeting's agenda, discussing in depth about the contents of the introductory presentations and the specific steps that will be followed to implement the co-design workshop."*
> *From minutes of a regional meeting 7*

Learning occurred at operational (micro), tactical (meso), and strategic (macro) levels (Bouw, 2021). The minutes of regional meetings showed learning on the operational level (micro),

BY-NC-SA 2024, Editorial Universitat Politècnica de València

focusing on tasks to be done like the previous example. Additionally, suggestions were made for strategic learning (macro), for example, on involving certain stakeholders in the CoVE.

> *"Does that stakeholder have any companies in their network which could integrate experiences about sustainable energy, the energy transition?"*
> *From minutes of a regional meeting 5*

Learning at transnational meetings seems to relate to the tactical level (meso). Good ways of working in transnational meetings were discussed, as were the definitions of general topics such as characteristics of good practices.

> *"Each session had a hands-on part to ensure participant engagement and that the new skills and methods were applied to practice immediately."*
> *From the report of transnational meeting 3*

Thus, after transnational meetings, an ongoing learning process occurred in regions on how to apply new practices learned and how to acquire additional knowledge and methods, which resulted in practical tasks (operational level) and long-term CoVE goals (strategic level).

4.3 Participation as a key issue found in transnational and regional learning

We found 12 fragments reporting struggles in regional meetings about the project approach, SEED partner participation, definitions, applications of new knowledge and methods and future collaborations. Seven fragments were found in the reports of the transnational meetings about preparation time, having the right persons present during the transnational meetings, a leaving project partner, unperformed tasks, and long discussions. Participation is a key factor influencing transnational learning, and absence may cause struggles in regional and transnational meetings. I*dentification,* a learning mechanism of boundary crossing could have played a role in this behavior. Cultural differences may have caused the behaviour of persons from one culture to be not accepted by others from other cultures. An example is described below; whether or not it is frowned upon when a person misses a meeting may be, in part, culturally determined.

The absence of relevant participants can stagnate learning as progression on learning goals cannot be achieved during the meeting. The presence and attendance of participants influenced learning in regional and transnational meetings.

> *"A difficulty was that during the transnational meeting in Bochum, many good practice responsible persons were not attending. Therefore, lots of questions were not answered."*
> *From the report of transnational meeting 2*

2024, Editorial Universitat Politècnica de València BY-NC-SA

The report explained that the workshop plan was adjusted to accommodate this situation. It discussed how to overcome this limitation and addressed this issue in follow-up meetings. During the next transnational meeting, a wider audience, including teachers, joined, which made it easier to solve the issues discussed.

In sustainability, travelling can be frowned upon due to its carbon footprint. However, visiting the good practices of other countries CoVEs brings a deeper level of learning that cannot be achieved through other methods, such as online meetings or reading about them.

> *"Being on site with the good practice offered a more practical approach to think about implementation possibilities because the work package leaders could see the full scope of the practice and ask direct questions about the implementation of the practice in Bochum."*
> *From the report of transnational meeting 2*

Thus, physical presence positively influences learning for an individual. Group presence stimulates learning between CoVEs through coordination as it supports overcoming boundaries by means of (e.g.) communication, procedures and tools and may lead to shared understanding and new (shared) rituals (Akkerman and Bakker, 2011). On an individual level, physical presence influences reflection on realising and clarifying the differences between practices to reflect on personal practices and that of others (Akkerman and Bakker, 2011). Transnational learning needs presence and commitment from CoVE members to be effective for regional learning and strengthening CoVEs in different countries.

5. Conclusions & further research

Three themes were identified in a preliminary analysis of the data: inter-CoVE learning, valuable learning experiences, and participation. Inter-CoVE learning is a two-way street between transnational and regional meetings and occurs through sharing expertise and knowledge. Transnational learning is about learning new collaboration and teaching practices to strengthen CoVEs. After the transnational meetings, an ongoing learning process emerged in the different regions about (1) what immediate tasks need to be taken and (2) what strategic goals need to be set to transform working and teaching practices and strengthen CoVEs. A key enabler in learning within regions and across borders is presence and commitment on individual and group levels. In the remainder of the project, we will study how learning within regions and across borders can be improved by interviewing participants, reviewing the literature, and organising specific workshops to develop a vision of regional and transnational learning. Further research could explore similar transnational and regional collaboration and learning to investigate whether our insights on learning occur in other contexts.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

This project received funding from the European Union's EACEA.A - Erasmus+, EU Solidarity Corps under grant agreement No 101056147. The authors would like to thank the participants.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Akkerman, S. F., & Bakker, A. (2011). Boundary Crossing and Boundary Objects. *Review of Educational Research*, 81(2), 132-169. https://doi.org/10.3102/0034654311404435

Bouw, E., Zitter, I., & De Bruijn, E. Multilevel design considerations for vocational curricula at the boundary of school and work. Journal of Curriculum Studies, 53(6), 765-783. https://doi.org/10.1080/00220272.2021.1899290

EC (2024). Centres of Vocational Excellence. Retrieved from (2-2-2024): https://ec.europa.eu/social/main.jsp?catId=1501&langId=en

Keay, J., May, H., & O'Mahony, J. (2017). Improving learning and teaching in transnational education: can communities of practice help?. In *Transnational and Transcultural Positionality in Globalised Higher Education* (pp. 67-82). Routledge.Van Mierlo, B., Halbe, J., Beers, P. J., Scholz, G., & Vinke-de Kruijf, J. (2020). Learning about learning in sustainability transitions. *Environmental Innovation and Societal Transitions*, *34*, 251-254.

Oonk, C., J.T.M.Gulikers, den Brok, P.J. , & Mulder, M. (2022). Stimulating Boundary Crossing Learning in a Multi-Stakeholder Learning Environment for Sustainable Development. *International Journal of Sustainability in Higher Education* 23(8), 21-40. https://doi.org/10.1108/IJSHE-04-2021-0156

Van de Plas, A., Vanyolos, I. , Vigani, M., & L. Vogel (2022). The Possible Implications of the Green Transition for the Labour Market. *European Economy Discussion Paper* 176, December 2022. Doi:10.2765/583043

2024, Editorial Universitat Politècnica de València BY-NC-SA

Collaborative Innovation in Energy: Integrating Design Thinking for Sustainable Product Development

Guilherme Victorino[a]

[a]NOVA IMS, Universidade Nova de Lisboa, Lisbon, Portugal

Abstract

Implementing innovative product development strategies within the energy sector presents unique challenges due to technological complexity, severe regulations, and environmental considerations. Product managers in this industry must navigate a complex web of collaborations across departments to ensure successful.

This paper explores the need to integrate human-centric factors in product development within the energy sector, emphasizing the shift towards collaborative and open approaches. Central to this shift is Design Thinking, which emphasizes iterative and collaborative efforts in driving innovation. The study focuses on the creation of a new line of home solar panels solutions using Design Thinking methodologies. Three workshops - inspiration, ideation, and implementation - are designed and implemented, offering a systematic approach prioritizing user needs, innovative solutions, and iterative refinement. Co-creation workshops engage stakeholders in each stage of the process, facilitating user research, brainstorming, and testing. Results highlight Design Thinking's effectiveness in fostering interdisciplinary collaboration and anticipating implementation challenges. The study underscores the potential of collaborative methods such as Design Thinking in navigating complex challenges and driving successful product development within the energy sector, ultimately contributing to sustainable solutions and organizational success.

Keywords: Sustainable energy; Solar panels; Design thinking; Co-creation Workshop

How to cite: Victorino, G.(2024) Collaborative Innovation in Energy: Integrating Design Thinking for Sustainable Product Development. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 395-402. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Implementing innovative product development strategies in the energy sector is inherently difficult due to the convergence of technological complexity, rigorous regulatory frameworks, long development cycles and environmental and social concerns (Gmelin & Seuring, 2014). Product managers in the energy industry must navigate an intricate web of collaboration with stakeholders from several departments to ensure the product's success (Hallstedt, Isaksson, & Öhrwall Rönnbäck, 2020). The ability to combine both human and technological factors is critical to product development success and plays an important role in the quality of the final offer that reaches the market (Marion & Fixson, 2021). The need to incorporate technological trends and industry compliance with the environment leads to long cycles of planning generally focused on the technical feasibility or the financial viability of the solutions .

In today's dynamic landscape, the imperative to cultivate sustainable solutions has led to a shift from traditional product development and business model generation towards collaborative and open approaches. The goal is to introduce the product's desirability layer into the process, requiring product managers to spend more time creating empathy with customers before delving into the solution's feasibility and viability components (Shapira, Ketchie, & Nehe, 2017). Central to this shift is the concept of Design Thinking, which emphasizes the iterative and collective effort of a diverse stakeholder group in driving innovation . In this paper, we explore how Design Thinking (DT) methodologies can serve as enablers of co-creation (Prahalad & Ramaswamy, 2004) and open innovation (Enkel, Gassmann, & Chesbrough, 2009), fostering collaboration and accelerating the development of sustainable energy solutions (Hoolohan & Browne, 2020).

2. Methodology

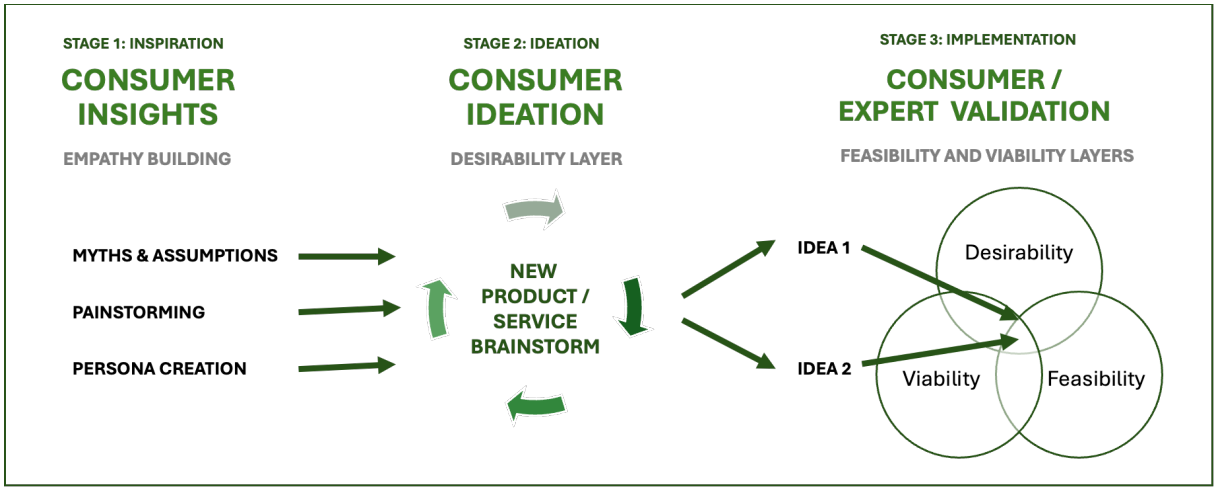
Our study will focus on the creation of a new line of home solar panels solutions that employed a design thinking methodology (Auernhammer & Roth, 2021) to integrate the marketing and sales teams' vision with the ultimate customer requirement as reflected thanks to collaboration sessions with residential consumers.

2.1 Design Thinking Approach

The approach used for the Design Thinking process consists of three main stages (Brown, 2008): inspiration, ideation, and implementation, each of which is critical for navigating the intricacies of product developement and sustainability (figure 1).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Figure 1. Design Thinking Iterative New Product Design Proccess



Source: adapted from Desirability, Feasibility and Viability Model (IDEO, 2015)

The initial stage, "Inspiration", focuses on immersing oneself in the topic area and getting deep user insights (Liedtka, 2018). This phase focuses on empathy, cultivating a thorough awareness of the user's requirements, emotions, and pain points. By establishing the potential areas for product innovation based on these findings, the framework is established for the next stage: ideation. The "Implementation" stage sees concepts transformed into actual solutions with real-world impact and reflecting about the feasibility and viability constrains before the deployment of the final solution.

To follow the three-stage Design Thinking method we have designed and implemented 3 workshops - inspiration, ideation, and implementation - offering a systematic approach to product development that prioritises understanding user needs, developing innovative solutions, and iterating on those answers through combining users and experts views (table 1).

Table 1. Design Thinking Research Methods

Stage	**INSPIRE**	**IDEATE**	**IMPLEMENT**
Goals	Generate consumer insights on how can we give more customers access to the benefits of Solar Energy by making the offer more attractive?	Thinking with customers about desirable solar energy solutions without considering limitations (technical feasibility or financial viability).	Critically discussing different solutions, defining their value proposition and customer experience from the end user's perspective.
Methods	**Group Discussion** Warm-Up Round What comes to your mind when we talk about solar energy? Myths and Assumptions about Solar Energy Solutions What kind of person uses solar energy?	**Ideation Workshop** 3 Brainstorming Rounds. For each persona the group brainstormed possible product or service solutions that address their specific needs, fears and constraints.	**Group Feedback Discussion** The consumer participant group was complemented with 2 Solar Energy Experts Confront the ideas of the previous sessions to validate the assumptions from the fesibility and viability perspectives.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

	Painstorming: What are the reasons for not joining a solar solution? **Personas Generation** We've created 3 types of user personas with different attitudes towards solar energy		Integration of spontaneous (consumer) ideas with expert solutions. Fill out the **Feedback Grid** regaring each idea: "Things that worked," "Needs to change," "New ideas to try," and "Questions we still have"
Number of Participants	13 participants. Written consent to participate in this study was obtained from all residential consumers. Convenience sample based on a heterogeneous group of participants with different profiles (age; energy invoice value; household size; type of house; rented or owned)		

Source: Own elaboration

2.2 Co-Creation Workshop: Inspiration Stage

The first session corresponds to the "Inspiration" stage of Design Thinking, in which the emphasis is on understanding and empathising with the needs and experiences of people (Heylighen & Dong, 2019). This session promotes empathy-building and user research by gathering end-users to discuss their wants, preferences, and pain areas with relation to residential solar panel solutions. Thirteen participants offered their experiences and thoughts, which provided essential information to the brainstorming process. The purpose of prioritising user-centric design principles is to guarantee that suggested solutions answer real-world difficulties and fit with user preferences, making them appropriate for the inspiration stage.

2.3 Co-Creation Workshop: Ideation Stage

The second workshop corresponds to the Ideation stage of Design Thinking, in which the goal is to generate creative solutions to the defined problem (Lee, Ostwald, & Gu, 2020). Participants engage in brainstorming activities while working with marketing experts and industry specialists to analyse the feasibility and viability of suggested solar panel solutions. Participants investigate several solution concepts and assess their technical feasibility, commercial potential, and financial viability using organised activities and scenario analysis. The insights gained from this workshop help to develop solution concepts and aid decision-making on implementation techniques, making it appropriate for the ideation stage.

2.4 Co-Creation Workshop: Implementation Stage

This workshop corresponds to the implementation stage of Design Thinking, which focuses on bringing ideas to life and scaling them for real-world effect (Randhawa, Nikolova, Ahuja, & Schweitzer, 2021). Participants engage in iterative development and testing activities by bringing together end users and marketing experts to negotiate the terms of compromise between desirability, feasibility, and viability dimensions. Stakeholders use guided talks and collaborative decision-making procedures to reconcile opposing viewpoints and establish

2024, Editorial Universitat Politècnica de València BY-NC-SA

mutually acceptable trade-offs. The workshop's goal is to match stakeholder expectations and goals, build agreement, and facilitate the creation of strong, balanced solutions that fulfil the demands of both end users and market players, making it appropriate for the implementation stage.

3. Results and Discussion

Design Thinking allowed for the collaborative exploration of diverse perspectives and ideas by emphasising stakeholder needs and fostering interdisciplinary collaboration. These findings emphasise Design Thinking's potential in producing collaborative creativity and inspire further research into its deployment in a number of contexts.

3.1 Co-creation workshop 1

The first co-creation workshop' purpose was twofold: 1) it had the intent of exploring customers' needs and pain points and 2) co-creating solutions with them. The key outcomes of the first part of the workshop are listed in Table 2, as well as the insights that the product development team derived from them. The discussion around the pain points of acquiring solar panels indicated that solar panels are perceived as products with high effort and low financial attractiveness. Participants mentioned they would need to spend a lot of effort in 1) learning and investigating the details about the product (financial and practical) before deciding to invest, 2) acquiring it, due to the installation, and 3) getting permission for installation in the case they live in an apartment. In financial terms, participants reported a perceived low financial attractiveness, with a high initial investment and long return on investment period. This type of product is also perceived as being only accessible to a certain type of customer with considerable wealth and knowledge about investments and technology.

Table 2 - Outcomes of co-creation workshop 1 and key insights

Reasons for not acquiring solar panels (pain points)	How participants perceive people who have solar panels	Key insights
• Living in an apartment • Installation cost and effort • Initial investment • Durability • Uncertainty about profitability • Long return on investment • Aesthetics • Complexity, doubts • Having to interact with condominium management • Too much work	• Cautious • Knows about investments • Interested in technology • Comfortable financially (being sustainable is expensive) • Greener lifestyle • Over 40 years old • Couple with children • Continuously plan and analyze their life	• Pain points are mostly associated with two key perceived disadvantages of installing solar panels: high effort (to learn about the service and/to acquire it/to get permission to install it) and low financial attractiveness. • Solar energy is perceived as being accessible to a specific type of customer (wealthy, knowledgeable)

Source: Data collected by author

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.2 Co-creation workshop 2

In the second workshop, participants brainstormed ideas that addressed the key pain points discussed previously. The most voted ideas and insights are described in Table 3. The three ideas presented in the workshop included three important elements that addressed the main pain points: 1) virtualization of the panels (invest in solar energy without having the physical panels on the customer's premises), 2) crowdfunding (diluting/sharing the initial investment) and 3) energy as a service (purchasing the solar energy, not the panels).

Table 3 – Most Voted Ideas and Key Insights

Most voted ideas	Key insights from ideas
• Prepaid solar energy card: invest in solar energy and spend your credit on different partners' services • Crowdfunded community solar park: invest on a small solar park to be built on a public lot • Solar garden: Energy company installs solar panels on a building and the energy is sold to the people living in that building	Most desirable ideas are associated with virtualization (invest in solar energy without having solar panels on customer's premises), crowdfunding (diluted/shared investment), energy as a service (purchasing the solar energy, not the panels).

Source: Data collected by author

3.3 Co-creation workshop 3

In the third co-creation workshop, the product development team presented two ideas, Remote Solar Panels and Solar Neighborhood, with the objective of collecting feedback from the participants. In general, both ideas received good feedback and the participants showed interest in the products, which validates their desirability. The inputs and ideas gathered through the feedback grid that directly helped shape the product are described in Table 4. The product development team leveraged this information to derive a list of improvements to be made to the prototype.

Table 4 – Feedback and Impact on Product Design

Idea	Key feedback from participants	Impact on product design
Remote Solar Panels	How does the customer materialize the investment?	Different package options for spending the acquired kWh
	The return on investment is not clear	Improved interface: highlighted benefits
	Is the customer affected by technical problems in the solar park?	Clarified value proposition: customer acquires kWh, not physical panels
	Can the acquired energy be used in more than one house?	Added feature: adding more than one energy contract to the app
	Does the company guarantee the return of the investment?	Clarified value proposition: investment in solar energy, not a financial investment (zero risk of capital loss)
Solar Neighborhood	Benefits for the participants depends on apartment area or energy consumption?	Simplied offer
	Could customers monitor the produced and consumed energy?	Accessible production/consumption data to each member of the community
	Offer based on installation area	Personalized offer based on simulation, drawing the available area for installation on a map
	Can businesses also become producers?	Offer available for B2B market

Source: Data collected by author

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4. Conclusion

In this paper we have analyzed a new product development process implemented with a product development team that embeds co-creation in the Design Thinking process, allowing for exploration and testing of ideas with participants (both customers and non-customers). The outcomes from both co-creation workshops support the validity of this approach towards generating and refining products that are innovative and human-centered. The presented case describes how this approach contributed to the development of two new products in the market.

Our findings offer a new understanding of how Design Thinking methodologies might contribute to co-creation and product development in the context of sustainable energy services. Co-creation emerged as an alternative, allowing stakeholders to collaborate and improve solutions to complex problems. Furthermore, Design Thinking accelerates concepts and clarifies future implementation issues, allowing for faster iteration and refinement.

We argue that the proposed approach is adequate for innovating in highly regulated and complex markets, such as the energy market. The Design Thinking approach focused on gathering valuable insights concerning the desirability of the new products (participants are allowed to brainstorm and get creative without knowing in depth all the restrictions in terms of viability and feasibility). The product development team then used this information as a base for their work. Knowing in detail all the feasibility and viability limits (legal, technical, financial, practical), the team refined and developed the ideas internally. In essence, the process is an iteration of internal and co-creation efforts: the team gathers insights through co-creation which then uses to develop the ideas, which then tests and develops through co-creation. The iterative nature of the process allows for a continuous try and fail approach, which is naturally expected in any innovation process.

In conclusion, this experiment illustrates how co-creation and Design Thinking work together to drive sustainable product development. By synthesising findings from 3 collaborative workshops, we help to further the conversation around collaborative innovation in sustainability. Our findings underline the need for comprehensive methods that stress stakeholder participation, interdisciplinary collaboration, and fast iteration. As organisations navigate the intricacies of sustainability concerns, co-creation and Design Thinking provide potential avenues for successful new product development.

Acknowledgements

This work was supported by national funds through FCT (Fundação para a Ciência e a Tecnologia), under the project - UIDB/04152/2020 - Centro de Investigação em Gestão de Informação (MagIC)/NOVA IMS.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Auernhammer, J., & Roth, B. (2021). The origin and evolution of Stanford University's design thinking: From product design to design thinking in innovation management. *Journal of Product Innovation Management*, *38*(6), 623–644.

Brown, T. (2008). Design thinking. *Harvard Business Review*, *86*(6), 84.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and open innovation: exploring the phenomenon. *R&d Management*, *39*(4), 311–316.

Gmelin, H., & Seuring, S. (2014). Determinants of a sustainable new product development. *Journal of Cleaner Production*, *69*, 1–9.

Hallstedt, S. I., Isaksson, O., & Öhrwall Rönnbäck, A. (2020). The need for new product development capabilities from digitalization, sustainability, and servitization trends. *Sustainability*, *12*(23), 10222.

Heylighen, A., & Dong, A. (2019). To empathise or not to empathise? Empathy and its limits in design. *Design Studies*, *65*, 107–124.

Hoolohan, C., & Browne, A. L. (2020). Design thinking for practice-based intervention: Co-producing the change points toolkit to unlock (un) sustainable practices. *Design Studies*, *67*, 102–132.

IDEO. (2015). Design Thinking Methods. Retrieved 9 May 2021, from https://www.designkit.org/methods#filter

Lee, J. H., Ostwald, M. J., & Gu, N. (2020). *Design thinking: creativity, collaboration and culture*. Springer.

Liedtka, J. (2018). Why design thinking works. *Harvard Business Review*, *96*(5), 72–79.

Marion, T. J., & Fixson, S. K. (2021). The transformation of the innovation process: How digital tools are changing work, collaboration, and organizations in new product development. *Journal of Product Innovation Management*, *38*(1), 192–215.

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of Interactive Marketing*, *18*(3), 5–14.

Randhawa, K., Nikolova, N., Ahuja, S., & Schweitzer, J. (2021). Design thinking implementation for innovation: An organization's journey to ambidexterity. *Journal of Product Innovation Management*, *38*(6), 668–700.

Shapira, H., Ketchie, A., & Nehe, M. (2017). The integration of design thinking and strategic sustainable development. *Journal of Cleaner Production*, *140*, 277–287.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Sustainable Planning for the Development of Site-Specific Run-Of-River Hydropower: A Case Study in the Gonovo River Catchment, Finschhafen District, Papua New Guinea

Tingneyuc Sekac[a], Nosare Maika[b], Sujoy Kumar Jana[a], Ora Renagi[c], Sammy Aiau[d] and Dapsy Olatona[c]

[a]School of Surveying and Land Studies, PNG University of Technology, Papua New Guinea
[b]ATCDI, PNG University of Technology, Papua New Guinea
[c]School of Applied Physics , PNG University of Technology, Papua New Guinea
[d]School of Electrical Engineering , PNG University of Technology, Papua New Guinea

Abstract

The research explores the integration of emerging technologies to support sustainable rural electrification planning. By merging advanced technologies, it comprehensively assesses environmental, social, and economic dimensions to unlock renewable energy potential, particularly in rural areas. Aligned with Sustainable Development Goal 7 (SDG-7), insights from the Transforming Energy Access-Learning and Partnerships (TEA-LP) workshop guide the research trajectory. Through the integration of scientific and engineering concepts, the study aims to efficiently identify and leverage renewable energy resources to meet community demands. Using a case study methodology, it evaluates the viability of run-of-river hydropower systems, meticulously analyzing topographical, hydrological, socio-economic, and environmental factors. Various configurations of run-of-river infrastructure are considered, with projections indicating potential net power outputs ranging from 81 to 336 kW at sites 1, 2, and 3 under low flow conditions. Risks such as infrastructure instability, flooding, and inundation are addressed during planning and design phases to achieve the targeted electricity output. Notably, the total electricity demand for 385 households inclusive of public institutes within, and surrounding the study region, stands at 598 kW. Sites 1 and 2 are capable of powering two villages each, while site 3 can supply four villages, contingent upon governance and monitoring of appliance usage.

Keywords: Run-of-river Hydropower, Sustainable energy planning, Renewable energy

How to cite: Sekaca T.; Maika N.; Kumar Jana, S.; Renagi,O.; Aiau, S. and Olatona,D. (2024) Sustainable Planning for the Development of Site-Specific Run-Of-River Hydropower: A Case Study in the Gonovo River Catchment, Finschhafen District, Papua New Guinea. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 403-412. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Amidst escalating global demand for sustainable energy solutions, renewable energy exploration takes precedence. Integrating emerging technologies aims to foster sustainable and affordable energy planning, especially in rural electrification. Comprehensive consideration of various factors, from community involvement to environmental risk assessments is vital throughout the process. In a case study conducted in the Gonovo river catchment, Finschhafen district, PNG, meticulous attention was given to bridge gaps, particularly in engaging rural communities during planning and designing phases. The objective is to calculate power needs accurately to meet rural community demands, ensuring the provision of affordable, reliable, and sustainable electricity.

The current research focuses on developing and implementing a technical workflow for micro run-of-river hydropower at site-specific locations. It integrates both scientific and engineering knowledge, although an in-depth engineering calculation of various components was not fully explored. According to Renewable Energy UK (2006) and concepts by JICA (2003, 2005, 2015), run-of-river hydropower systems utilize diverted river flow directed towards a forebay or head tank via settling basins and headrace connections. Sometimes, closed pipes are used to maintain sufficient pressure for effective power production at the powerhouse. Careful planning and design are essential to avoid risks like flooding, landslides, and inundation, ensuring longevity of electricity production. Topographic and hydrological investigations are crucial feasibility stages to assess energy potential at each site and determine if the calculated power meets rural community needs.

Run-of-river hydropower offers advantages like reduced construction time and costs due to the absence of large reservoirs, as mentioned by Ibrahim et al. (2019). This method also mitigates inundation risks for nearby communities, as highlighted by Kumar and Katoach (2014). Despite abundant renewable resources, many rural communities lack access to sustainable electricity. This study addresses this issue by proposing holistic approaches to meet expanding community needs sustainably. It emphasizes balancing environmental, social, and economic factors to benefit current and future generations. Hydropower stands out among renewable energy sources, constituting approximately 2.5% of the world's energy resources and contributing around 15.9% to global electricity generation, as stated by Haddad et al. (2011), and Safarian et al. (2019).

The current research aim at assessing community interest and willingness to participate, conducting supply-demand assessments, evaluating potential renewable energy sources, assessing environmental risk factors, and quantifying the net power to meet projected demand. Aligned with the United Nations' Sustainable Development Goal 7 (SDG-7), the research aims to develop a workflow that ensures access to affordable, reliable, and sustainable energy. In support of SDG-7, the TEA-LP workshop in 2023 emphasized the

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

urgent need to bolster renewable energy capacity, especially in developing countries. The workshop outlined strategies and plans for a Master's course tailored to sustainable energy development in expanding communities, with a particular focus on developing countries. As the current research is not really tied into education sector, however the research aid into populating knowledge background to develop and build teaching and study materials inline to sustainable and affordable energy development and supply within Rural communities, especially for developing countries. The workflow of reaching to affordable and sustainable energy planning, designing and development was developed in the present research that can be used to equipping students with additional skills and knowledge, coupled with engineering concepts, to innovate sustainable energy systems in rural communities.

2. Methods

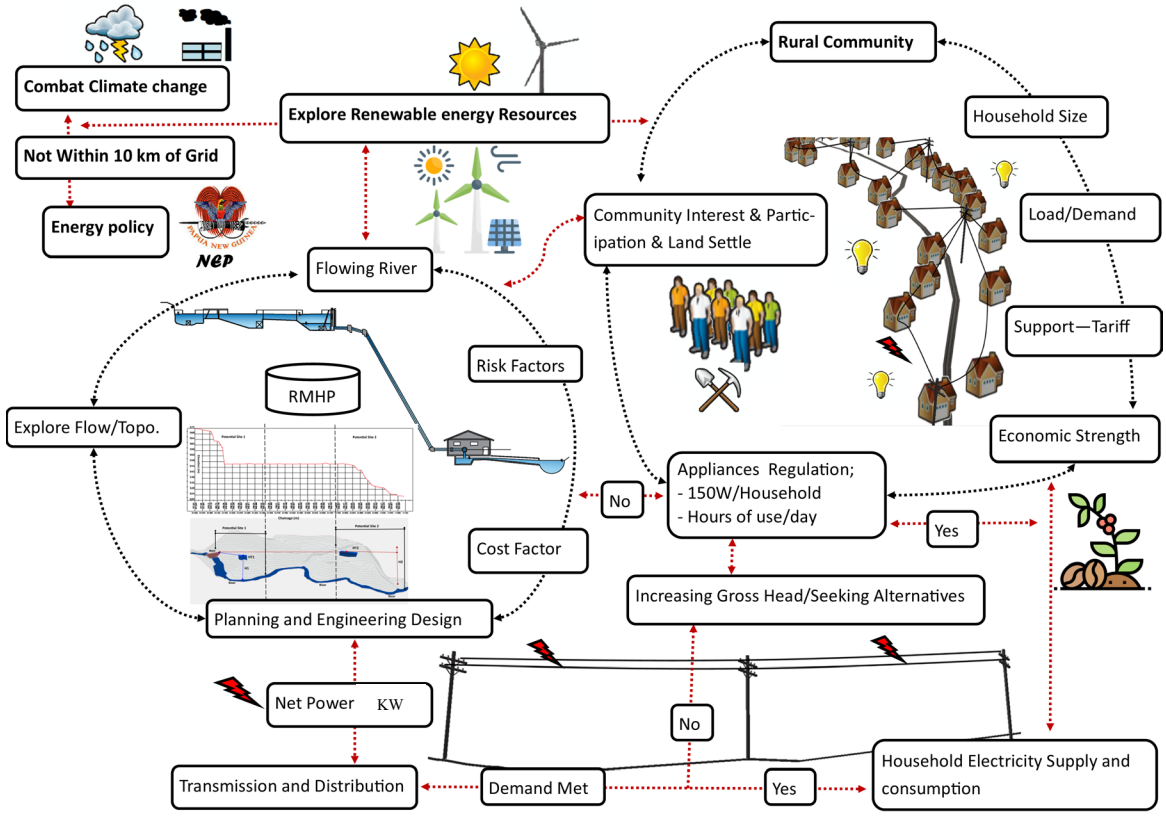
T. Sekac et.al 2023 conducted a pre-feasibility study in the Mape catchment region of the Finschhafen district, PNG. They identified numerous potential sites for run-of-river hydropower. Building on this, the current study focuses on the Gonovo river which is the western side tribute of major Mape river (Figure 3). The Gonovo river catchment area from where weir intake is proposed, was estimated to be 1670 hectares. During field visits, the researchers assessed potential inundation zones and analyzed data to evaluate the impact, including water backlog potential. The study also involved visits to rural communities such as Hapohondong, Kangaruo, Manga, Zinko, and Makini station, all lacking electricity and situated 10 km from the main power grid. The study classified the hydropower scheme as Micro Hydropower (MHP), considering flow discharge and effective head. It proposed a cross-flow turbine with 80% efficiency for power generation, aligned with literature from Sinagra et al., (2014) and Kaunda et al., (2012). Figure 1's flow chart details the processes and method followed. The research employed three approaches, as depicted in the flow chart: 1. Assessing existing policies and climate actions. 2. Identifying renewable energy potential, designing, and calculating power considering costs, risks, and flow characteristics. 3. Integrating rural communities to assess demand, socio-economic factors, and electricity supply.

Utilizing SDG7 goals and TEA-LP workshop insights, the study aimed to enhance sustainable energy development in developing countries. The workflow developed can be integrated into course modules to facilitate student learning. Focusing on the study sites depicted in Figure 3, the Gonovo River's discharge was continuously monitored for four years. Figure 2b shows the mean duration curve of monthly flows during this period. Peak flood discharge reached 4.32 m^3/s, with a low of 0.46 m^3/s. The design flow for power calculation, derived from the flow between 70% and 90% of the time, was 0.5 m^3/s. Power potential estimation for the run-of-river hydropower system in the current study employs the equation: Power (P) = Discharge (Q) × Net Head × Gravitational constant (9.81 m/s^2) × Water Density (1000 kg/m^3) × Turbine

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Efficiency (80%) (Sinagra et al., 2014, Kaunda et al., 2012, T. Sekac et al., 2017 and 2023, Dessie M, 2020, and Sammartano et al., 2019). In the calculation process for the Micro Hydropower (MHP) scheme, 10% losses for pipeline and penstock were factored into the net head calculation to derive the net power in KW. The research used a comprehensive approach for landscape modeling, encompassing tasks like assessing elevation, analyzing slope and terrain profiles, and planning structures such as weirs, intakes, diversion pipes, and forebay/head-tanks. This method integrated advanced technologies like UAV drone surveys, RTK GNSS solutions, and traditional terrestrial surveying methods, alongside software tools such as Civil 3D and ArcGIS. Comprehensive data collection aimed to plan each infrastructure effectively to meet community power demands. Land availability and rugged terrain constrain further investigation. Additionally, transport and equipment shortages pose challenges and limitations to the research.

Figure 1: Rural base micro hydropower planning and development methods



Source: T.Sekac (2024)

The planning process included land discussions and settlements involving landowners and communities, making the project a community-based initiative for electricity development. Portions of land were negotiated for use under agreements with landowners and resident communities. Five villages comprising 385 households (Hapohondong (232), Kangaruo (84), Manga (34), Zinko (29), and Makini (9)), along with public facilities like schools and health

 BY-NC-SA

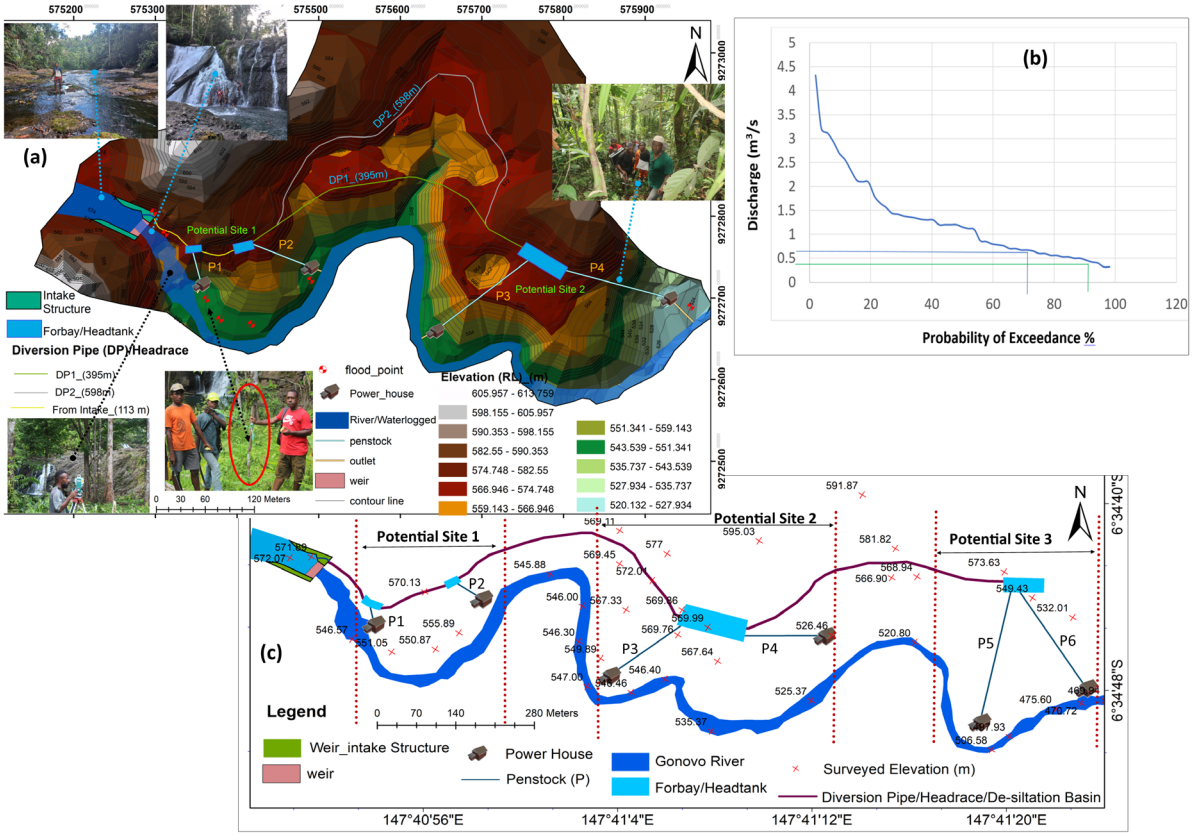
centers, were assessed for community demand and socio-economic factors. Total energy demand was calculated, and Figure 3 depicts the villages' proximity to MHP sites. Communities were interviewed regarding tariff plans, appliance usage, and regulations. Economic strength per household was evaluated and discussed.

3. Results and Discussions

The design flow of 0.5 m³/s was utilized to compute power at each site, factoring in various net heads. Throughout the study, three potential sites were pinpointed while keeping the weir location fixed (Figure 2 a, c). Considering site topography and the low design flow, the weir/intake site was fixed at RL 572 meters, and the weir height was proposed at 1.5 to 2 meter with crest length of 50 meter wide. The near walls are at steep slope of 80 to 90 %. The objective was to determine which site could generate sufficient power to meet community demand. Surface modeling was conducted to analyze slopes and elevation, facilitating the planning of MHP infrastructures. Landscape designed output were utilized for MHP infrastructure planning (Figure 2a). Based on the designed RL, longitudinal profiles of each infrastructure were developed (Figure 4a-f). The aim was to attain the necessary power output to meet community demand while enhancing sustainability in terms of cost and risk factors during construction. The designed Longitudinal profiles and slopes at potential site 1, P1 (Figure 2 a and c), are depicted in Figure 4a-f. At the intake, water was planned to be diverted at designed RL 572.4, with a minimum slope for de-siltation basin and diversion pipe/headrace at -1.23% to -3% toward the head-tank. The head-tank was positioned at designed RL of 571 meters away from the intake, achieving a 1.4 meter drop over the 77-meter distance.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 2: Optimal Planning for MHP infrastructures; a. Surface Modeling, b. Flow duration curve, c. Potential sites with different size Penstock



Source: T.Sekac (2024)

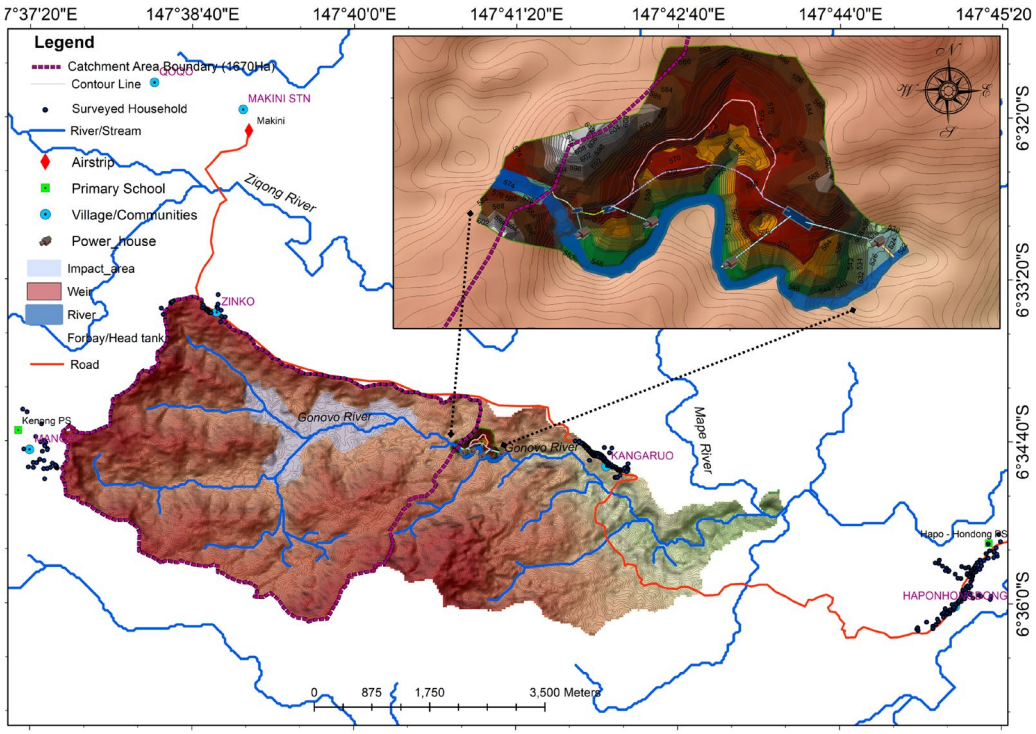
The designed RL and slope were held constant for either closed pipe or open channel diversion to estimate sufficient power. The open water channel profile for the penstock design from the head tank to the power house at potential site 1, P1, is shown in Figure 4e (adapted from JICA, 2003, 2005). Peak flood level data guided the placement of the power house at a low altitude at potential site 1, P1. The total distance from weir intake to power house is 102 meters (Table 1 and Figure 4a,b,c, and f). Following careful consideration of landscape, cost, and risk factors, the power house was planned at a designed RL of 748-749m (Figure 4f). The penstock was designed with a 99.32% slope, located 25 meters from the head-tank. Gross head was 23 meters, with 10% losses factored in for net head calculation (20.7 m). With a low flow of 0.5 m³/s and net head of 20.7 m, and 80% turbine efficiency, net power at potential site 1, P1, was 81.23 kW. Similar calculations and design approaches were applied to potential sites 2 (P3, P4) and 3 (P5, P6), refer figure 2 a, and c, including table 1.

Two headrace routes, DP1 and DP2 (figure 2a), are proposed for sites 2 and 3. DP1 is shorter but requires more civil engineering work, while DP2 is longer but needs less civil engineering. DP2 may incur higher material costs, but utilizing on-site resources could offset expenses. The survey of five villages totaling 385 households reveals a total power demand of 598 KW.

 BY-NC-SA

Hapohondong requires an average of 311 KW, Kangaruo 121 KW, followed by Zinko, Manga (Kenong), and Makini at 68, 73, and 25 KW respectively. Figure 3 depicts potential site locations relative to each village. The assessment of community economic strength indicates involvement in cash crops, small businesses, and government employment for income generation. Positive results suggest support for tariff plans, enabling community participation in electricity planning, promoting sustainability, and ensuring affordability.

Figure 3: Gonovo river catchment and villages



Source: T.Sekac (2024)

The net power at potential site 1 can support 20 to 30 households, benefiting Makini or Zinko community. Site 2, P4, could supply Kangaruo village and nearby areas like Makini, with potential for shared power to Zinko. Site 3, P6, may supply Kangaruo, Zinko, Manga, and Makini with regulated appliance use. Community power demand was calculated based on appliance usage rates, gathered from surveys across five villages. Power supply depends heavily on appliance usage control and hours of operation. For potential site 3, P6, supplying multiple communities, stringent monitoring of appliance use is essential for affordable supply.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

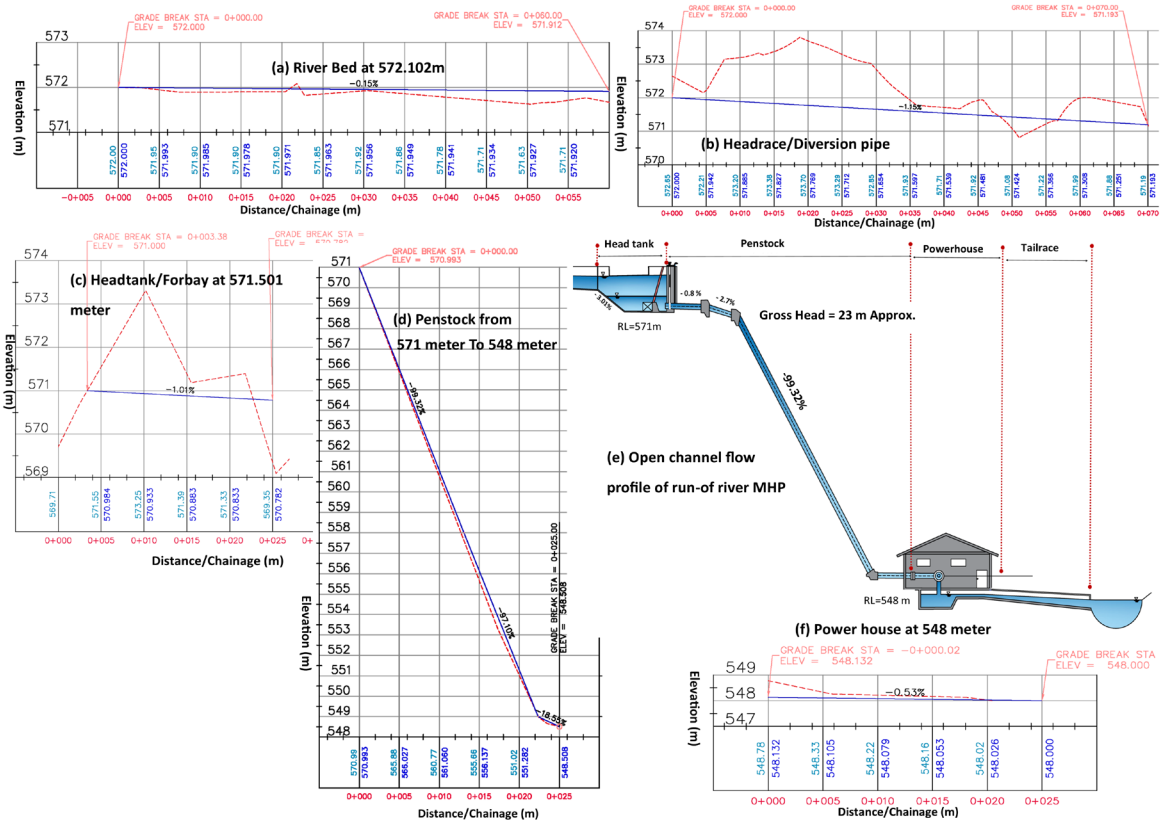
Table 1: Calculated Net Power at Site 1, 2 and 3

Potential Site	Penstock(P)	Distance from Weir/Intake to PH (m)	Slope (%)	Net Head (10% loss) (m)	Turbine Efficiency (80%)	Low Flow (m^3/s)	Net Power KW
1	P1	102	99.32	23/20.7	0.80	0.5	81.23
	P2	206	38.23	22/19.8	0.80	0.5	77.69
2	P3	650	32.56	23/20.7	0.80	0.5	81.23
	P4	711	60.23	45/40.5	0.80	0.5	158.76
3	P5	1175	67.23	68/61.2	0.80	0.5	240.15
	P6	1189	78.34	95/85.5	0.80	0.5	335.50

Source: own elaboration

Further investigation downstream may yield sufficient power for entire communities, contingent upon land availability, risk, and cost considerations.

Figure 4: Run-of river hydropower infrastructures profile layout for Site 1, P1



Source: T.Sekac (2024)

4. Conclusion and Recommendation

In conclusion, the demand for sustainable electricity solutions is evident in today's evolving technological landscape. Achieving a win-win scenario requires integrating various technologies, from geographical sciences to engineering. This synergy is crucial for addressing challenges arising from the growing demand for sustainable energy. Our research

 BY-NC-SA

focuses on assessing specific sites for run-of-river hydropower, emphasizing meticulous planning and design to optimize sustainability, affordability, and efficiency. By analyzing environmental, topographic, social, and hydrological factors, we calculated the potential power output for each site and estimated the supply-demand rate by analyzing community responses. Site 3 could potentially benefit a maximum of four communities in a more affordable means under proper regulation of appliance usage. Our planning framework emphasizes sustainability, affordable electricity use, minimal community impact, and the promotion of infrastructure longevity. Future research will delve into conveying system losses and structural evaluation for a more nuanced validation of power output. In the realm of academic research and development, our commitment to advancing sustainable energy solutions, aligned with SDG-7, and disseminating ideas and knowledge to the growing student population, remains steadfast.

Acknowledgement

The author expresses sincere gratitude to the PSR&IC at PNG University of Technology for the invaluable financial support provided for the successful execution of the research project Phase 2. The author extends heartfelt thanks to the esteemed Mape community, including Hapohongdong, Kangaruo, Zinko, Manga and Makini communities for their unwavering support and cooperation throughout the field survey and data collection endeavors.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bozorg-Haddad, O., & Moradi-Jalal, Mahdi & Mariño, Miguel. (2011). Design—operation optimisation of run-of-river power plants. Water management. 164. 463-475. 10.1680/wama.2011.164.9.463.

Dessie. M (Online). Chapter 3: Planning of Hydropower projects. Hydropower engineering, Faculty of civil and water resources engineering. http://ndl.ethernet.edu.et/bitstream/123456789/79504/8/Chapter%203%20hydropower%20development.pdf.

Ghosh, T. K., & Prelas, M. A. (2011). Energy resources and systems: Volume 2: Renewable resources. Springer Netherlands. https:// doi. org/ 10. 1007/ 978- 94- 007- 1402-1.

Ibrahim, M., Imam, Y., & Ghanem, A. (2019). Optimal planning and design of run-of-river hydroelectric power projects. Renewable Energy, 141, 858–873.

https://www.sciencedirect.com/science/article/abs/pii/S0960148119304859.

Kumar, D., & Katoch, S. S. (2014). Sustainability indicators for run of the river hydropower projects in hydro rich regions of India. Renewable and Sustainable Energy Reviews, 35, 101-108. https://www.sciencedirect.com/science/article/abs/pii/S1364032114002093.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Renewable Energy UK, 2006. Run of River Hydro Power. Available at: http://www.reuk.co.uk/wordpress/hydro/run-of-river-hydro-power/

Safarian, S., Unnthorsson, R., & Ritcher, C. (2019). A review of biomass gasifcation modelling. Renewable and Sustainable Energy Reviews, 110, 378–391. https://www.sciencedirect.com/science/article/abs/pii/S1364032119303090

Sammartano, V., Liuzzo, L., Freni, G. (2019). Identification of Potential Locations for Run of-River Hydropower Plants Using a GIS-Based Procedure. Energies, 12, 3446. https://doi.org/10.3390/en12183446.

Sekac, T., Jana, S.K, Maika, N., Aiau, S. (2023). Geospatial Technology for Hydropower Site Selection and Rural Electrification Supply-Demand Analysis - A Case Study in the Yabem/Mape Rural of Finschhafen District, Papua New Guinea. FIG Working Week, FIG Congress, 28 May – 1 June, 2023, Orlando, Florida, USA. https://fig.net/resources/proceedings/fig_proceedings/fig2023/papers/ts05j/TS05J_sekac_sujoy_kumar_et_al_11822.pdf.

Sekac, T., Jana, S.K. & Pal, D.K. (2017). Identifying potential sites for hydropower plant development in Busu catchment: Papua New Guinea, Spat. Inf. Res. (2017).,Springer publication-Singapore, ISSN: 2366-3286 (print version) ISSN: 2366-3294 (electronic version) https://doi.org/10.1007/s41324-017-0145-z002.

Sinagra, M., Sammartano, V., Aricò, C., Collura, A., Tucciarelli, T., 2014. Crossflow turbine design for variable operating conditions. Procedia Eng. 70, 1539–1548.

Chiyembekezo S. Kaunda, Cuthbert Z. Kimambo, Torbjorn K. Nielsen, "Potential of Small-Scale Hydropower for Electricity Generation in Sub-Saharan Africa", International Scholarly Research Notices, vol. 2012, Article ID 132606, 15 pages, 2012. https://doi.org/10.5402/2012/132606

JICA, (2005). Small hydropower planning in Northern Laos. Small hydro visual guide.

JICA, (2003) Study on Rural Energy Supply with Utilization of Renewable Energy. Manual for Micro-hydro power Development in Rural Areas in the Republic of Indonesia.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Knowledge dissemination and diffusion towards regional ecosystems

Frans van den Akker[a], Jorrit Bock[a] and Fionna Heuff[a]

[a]Royal HaskoningDHV, the Netherlands

Abstract

The current multifaceted transition in energy and digital realms demand agility and adaptability for companies, governments and individuals. It is imperative that innovations are rapidly operationalized within practical fields, allowing for immediate application by businesses and organizations. This requires a workforce that is not only appropriately educated but also sufficiently equipped with the necessary skills and tools. Early engagement of end-users in these processes is crucial, as is the ability for educational institutions to swiftly adapt their curricula to meet emerging needs. This ensures that the younger generation is equipped with the relevant competencies and skills. Furthermore, it is not sufficient for components of our infrastructure to operate in parallel; they must function in an integrated and collaborative manner.

This necessitates intelligent structuring, where innovation, employment, and education are closely interlinked. We refer to this paradigm as a "Learning Community". Through various initiatives such as Fieldlabs, Skillslabs, Centres of Expertise, Centres for Innovative Craftsmanship, lectureships, and practical research professorships, this concept is being actualized with a particular emphasis on secondary vocational education, higher professional education, and corporate learning environments. Naturally, these transitions also mandate modifications within the labour organizations themselves, as fields of work and professional tasks evolve in response to rapid technological and economic advancements. The critical question is how we can facilitate the workforce's growth and adaptation within this changing landscape, potentially through social innovation and lifelong learning strategies.

Keywords: Digital transformation; Learning Community; Knowledge diffusion; Social innovation; Labour productivity.

How to cite: Van den Akker, F.; Bocka, J. and Heuffa, F. (2024) Knowledge dissemination and diffusion towards regional ecosystems. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 413-420. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The energy sector plays an important role in the Dutch economy and the societal challenges for which the sector must provide solutions. The sector is working on the transition to a low-CO_2 economy, where innovation and diffusion of acquired knowledge are essential. Knowledge diffusion refers to the exchange of knowledge, ideas, and technologies among different actors in the innovation system. Knowledge diffusion can take place in various ways, through formal channels, such as publications, conferences, and workshops. However the energy industry mainly looks at networks and public-private collaborations such as Learning Communities as a means of disseminating knowledge and organizing work, learning, and innovation together. A learning community is a group of people who share common goals and attitudes and meet regularly to collaborate.

These Learning Communities can therefore play a crucial role in stimulating continuous knowledge sharing and innovation within the sector. The collaboration within Public-Private Partnerships (PPP) in Learning Communities then creates a significant impact on the efficiency and effectiveness of innovative processes within various sectors, including small and medium-sized enterprises (SMEs), which are an important participant in these ecosystems.

Learning communities, in which public and private parties learn, innovate and work together, are used as a means of disseminating knowledge. At the moment, there are already about 100,000 hard-to-fill vacancies in technology and ICT (Topsector Energie, 2023) in the Netherlands and these shortages will only increase in the coming years. This jeopardizes both the digital and the energy transition. These shortages in the labour market and competitive position require higher labour productivity.

Learning Communities generally function well and have a positive influence on knowledge diffusion, but there is also room for improvement on various aspects, such as the form of collaboration, communication, funding, regional and national significance, and evaluation of the impact. This positive evaluation underscores the value of shared efforts and the synergy that arises when multiple entities join forces.

SMEs report substantial benefits from participating in a PPP (Royal HaskoningDHV, 2024). These benefits include access to new knowledge, networks, and innovative collaboration models that might otherwise be out of reach. We advocate for sufficient variety within the innovation, work and learning activities of the Learning Community to engage SMEs as learning companies, as hybrid teachers, as innovation partners as speakers or otherwise to serve SMEs and to make the threshold for participation as low as possible.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Companies often see themselves as co-creators and facilitators within PPP initiatives. These roles enable them to actively contribute to the design and implementation of projects, bringing in their own expertise and resources. The drivers for companies to participate in a PPP are diverse; however, the emphasis is mainly on knowledge creation, co-creation, and reducing research costs. Such collaborations provide companies with a platform for sharing risks and costs and increasing innovative capabilities.

The reasons for companies not to participate in a PPP vary, but often center around a lack of trust, differences in values and objectives, or the absence of a clear mutual benefit (Royal HaskoningDHV, 2024). It is essential that PPP initiatives address these concerns to promote broad participation and engagement.

This paper shows that there is a wide range of tools for setting up, scaling up, and monitoring the learning ability of a Learning Community and provides an entrance to this toolkit. We advocate for attention to this toolkit but especially for the skills and mindset of the Learning Community program managers, we advise active knowledge sharing between facilitators and process guides possibly in combination with the network of transition brokers and Webbers. We advocate for scaling up existing Learning Communities with pilot/lab facilities because these shared facilities are the main reason for knowledge institutions to participate in a Learning Community.

2. Collaborative learning

2.1 The need for collaborative learning

Rapid transitions such as the energy transition require agility. We want innovations to quickly yield results in practice, so that companies and organizations can quickly apply the innovations, and that people are adequately educated and equipped for this. We want users to be involved in this process at an early stage and that education can quickly set up the programs that are needed, so that young people are educated with the right competencies and skills. And we want parts of the infrastructure to work with each other, not next to eachother. This is a matter of smart organization: organizing innovation, work, and learning close to each other. We call this concept Learning Community.

Lifelong Learning (LLL) within an SME in the energy sector is a crucial factor for the company's growth and the personal development of the employees. Keeping up with process technological and digital innovations requires a continuous update of skills and knowledge of the staff and management to remain competitive.

Knowledge diffusion can take place in various ways. This can happen through formal channels, such as publications, conferences, and workshops, but the chemical industry

BY-NC-SA 2024, Editorial Universitat Politècnica de València

mainly looks at networks and public-private collaborations like Learning Communities as a means of spreading knowledge and organizing work, learning, and innovation together.

Attention to this is also necessary to align with the ambitions of the young people who are currently entering the labor market. These predominantly belong to Generation Z, born between the mid-90s and early 2010. This generation grew up in an era of rapid technological progress and digital connectivity, which strongly influences their perspectives and expectations of the labor market. Generation Z values personal and professional development highly. They are looking for employers who invest in their growth and education and often prefer those organizations that can offer them active learning opportunities. This generation is extremely competent with digital technology and expects their employers to use modern technological tools and platforms for training and development. They are often self-directed in learning via online sources and platforms. They find flexibility in learning and working important. They value autonomy and the ability to determine their own learning paths, often with a preference for online and on-demand learning resources. It is therefore important that SMEs scrutinize their own learning culture to remain an attractive employer and to be able to bind and captivate employees. This reasoning probably applies just as strongly to large companies and knowledge institutions, although due to the scale, other issues also play a role there, such as the question of how an Life-Long-Learning (LLL)-strategy can be implemented throughout the entire organization and what governance and work processes are needed for this.

2.2 Types of Collaboration

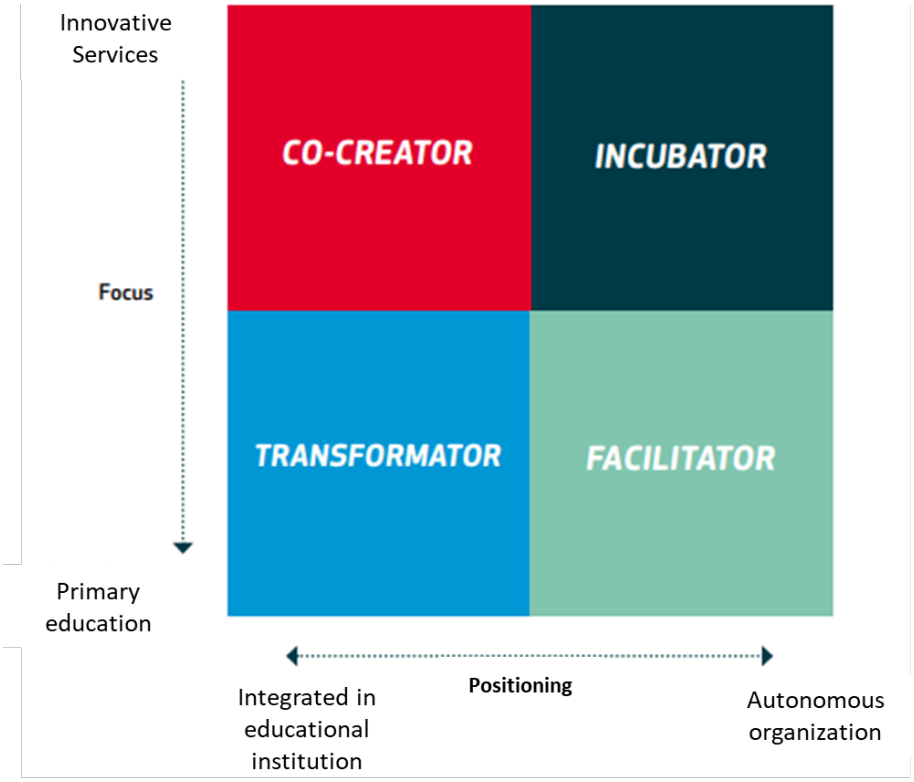
Public-private collaboration between vocational education and business can take many forms. One of these forms are the Centres for Innovative Craftsmanship and Centres of Expertise. They focus primarily on increasing and accelerating innovations. The Centres are innovation incubators where economic, social, and societal value is created for education, entrepreneurs, and government. New forms of collaboration are developed, tested, and scaled up. They thus form the experimental space for the vocational education of the future. The participating parties in collaboration can choose a role and focus, so the collaboration can be more focused on the development of new modules for education or on the application of innovations within the participating companies. These different approaches to innovation and positioning are also described in the handbook for Public-private collaboration (Katapult, 2015) in a 2x2 matrix (figure 1) where each quadrant has been given its own typification:

- Cocreator: In the cocreator-type PPP, public and private parties work together to jointly create new projects or initiatives.
- Incubator: In the incubator-type PPP, the public party acts as a supporting partner for facilitating innovation and stimulating entrepreneurship in the private sector.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- Transformator: In transformation, there is a focus on renewing education, with the private party taking on the role of advisor.
- Facilitator: The facilitator-type PPP focuses on a facilitating role itself to support the collaboration between the parties.

Figure 1: Quadrant depicting approaches to innovation.



Source: Adapted from Katapult, 2015

2.3 Reasons for collaboration

In addition to the role that a party can take, it can also have various reasons to enter the collaboration. This can be divided into the following categories:

- Stimulating regional development: the collaboration strengthens the regional network, and certainly, the Universities of Applied Sciences (HBOs) and Regional Training Centres (ROCs) often depend on the regional network.
- Reducing research costs: by dividing the costs over several parties, possibly also by applying for subsidies. ‘
- Creation of new knowledge and the combination of knowledge and co-creation.
- Developing new skills for participants. In this way, the collaboration is consciously used as a means for employees to develop themselves.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Use of shared facilities as a form of a sharing economy. This allows the SME to access facilities that would otherwise be inaccessible, such as laboratories, analytical equipment, or process technological test setups. The PPP can also take care of all additional permits and required facility services.
- Consortium formation for the purpose of subsidizing joint innovation. It is often not feasible for an SME to write a subsidy proposal independently, the consortium, with or without the help of an innovation intermediary, can often do this.

2.4 Successful collaboration

Previous research has been conducted into the learning culture of learning networks. OXFAM NOVIB, among others, looked at the interaction between the various members of a network in which learning takes place (Smith et al., 2007). The focus was mainly on networks where there are major differences between participating parties. A situation that certainly plays a role in a learning network often made up of SMEs, government, large companies, technology suppliers, colleges and universities. There are differences in e.g. culture, objectives, resources, size and knowledge. The cited research has identified several elements that reflect a positive culture of collaboration, and which can also be used as a checklist/assessment to assess a specific collaboration;

- **Openness and trust**: Participants in a learning network should be open to sharing information, ideas and experiences with others. Trust is essential to create a safe environment in which this is possible.
- **Equality**: In a learning network, the contributions of all participants are valued equally, regardless of their organization or hierarchical position.
- **Reflection**: Participants are encouraged to critically reflect on their own experiences and practices and those of others. This helps to gain new insights and improve existing practices.
- **Common goals**: Learning networks aim to achieve common objectives, such as solving shared problems or fostering innovation in a particular field.
- **Active participation**: Participants are encouraged to actively participate in discussions, workshops, trainings and other learning opportunities within the network.
- **Flexibility**: Learning networks are often flexible and can adapt to changing circumstances and needs

Collaborative success is a well-researched topic, and several models and frameworks have been proposed by various authors and researchers. One of the most well-known frameworks for understanding collaborative success is the "Collaboration Success Framework" by Mattessich, Murray-Close, and Monsey, published in 2001.

2024, Editorial Universitat Politècnica de València BY-NC-SA

This framework highlights six interconnected elements for a successful collaboration:

- **Characteristics of participants**: The traits, skills, and motivations of individuals participating in the collaboration.
- **Organizational Process**: The structure and decision-making processes of the collaborating organizations.
- **Communication**: The effectiveness of communication channels and information exchange between participants.
- **Purpose**: The clarity and alignment of shared goals and objectives between the collaborating parties.
- **Resources**: The availability and allocation of resources to support cooperation.
- **External support**: The presence and influence of external factors and support systems on cooperation.

The "Diffusion of Innovations" framework, also known as the Diffusion of Innovations model, was developed by the sociologist Everett M. Rogers. (Rogers, 1962). The model focuses on understanding the spread of new ideas, products, or technologies within a social system. It is often used to analyze why and how innovations spread through different groups and over time.

Rogers' framework consists of five elements that influence the diffusion of innovation; innovation impact, communication channels, the social system, time and adoption willingness.

The diffusion-of-innovations model has proven useful in understanding how new ideas and technologies spread across different social groups. It has found applications in diverse fields, such as marketing, technology adoption, and healthcare. By understanding the factors that influence innovation adoption, organizations can develop strategies to promote the adoption and dissemination of their innovations.

3. Conclusion

This paper provides a review of the need for learning communities, besides provides a review of frameworks and models that can be used by Learning Communities to improve forms of cooperation and innovative knowledge diffusion, which can optimize labourproductivity of concerning sectors. It highlights the importance of digital transformation, digital maturity, and social innovation specifically in the Netherlands, which faces challenges such as international competition, sustainability legislation, and labourmarket shortages. The benefits of learning in a community, such as openness, trust, equality, reflection, and common goals, are discussed, as well as the characteristics of successful collaboration, such as communication, purpose, resources, and external support. The paper also provides

BY-NC-SA 2024, Editorial Universitat Politècnica de València

guidelines and tools for assessing the current position and the potential for further development of Learning Communities, and emphasizes using learning community as a means to improve labourproductivity.

Overall, learning communities can contribute collaboratively by providing a comprehensive and practical overview of the key concepts, challenges, and opportunities in the sector. Using existing methods and tools for measuring the impact of learning communities and identifying gaps or challenges in the existing is essential.

Acknowledgements

We would like to disclose that the authors of this paper work at an independent engineering and consultancy firm that has commercial interests in the topics discussed in this paper. However, we would like to clarify that this did not influence the work reported in this paper. Our company's commercial interests are in line with the research presented in this paper, and we believe that our expertise in this area has helped us to provide valuable insights.

We would like to disclose that this research was funded by the Erasmus+ program. We would like to clarify that the funding did not influence the work reported in this paper.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Royal HaskoningDHV (2024), Kennisdiffusie binnen Chemical Learning Communities, ChemistryNL, https://chemistrynl.com/learning-communities/

Katapult (2015). Publiek privaat innoveren, *https://www.wijzijnkatapult.nl/files/downloads/Kennisbank/Handboek_Publiek_Private_Samenwe.pdf*

Mattesich, P.W., Murray-Close, M. Monsey, B.R. (2004). Collaboration: What Makes It Work, 2nd Edition A Review of Research Literature on Factors Influencing Successful Collaboration. Amherst H. Wilder Foundation, St. Paul MN, ISBN 9780940069329

Smith, L., Claborne, S. & Ojelay-Surtees, B. (2007). Building Trust in Diverse Teams: The toolkit for emergency response. Oxfam GB. ISBN 978-0-85598-615-5. https://policy-practice.oxfam.org/resources/building-trust-in-diverse-teams-the-toolkit-for-emergency-response-115413/

Topsector Energie (2023). Arbeidsbesparende innovaties. https://topsectorenergie.nl/nl/maak-kennis-met-tse/human-capital-agenda/arbeidsbesparende-innovaties/

Rogers E. M. (1962). Diffusion of innovations. Free Press of Glencoe

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Collaborative Reskilling: The Partnership of Hellenic Electricity Distribution Network Operator and University of West Macedonia, Greece, in Advancing Smart Electricity Grids

Evangelos Boutsiadis[a], Kimon Koulierakis[a], Dimitrios Tsiamitros[b], Dimitrios Stimoniaris[b], Theofano Kollatou[b], Athina Krestou[c] and Konstantinos Karamarkos[c,d]

[a]Hellenic Electricity Distribution Network Operator (HEDNO), Greece

[b] Department of Electrical and Computer Engineering, University of Western Macedonia, Greece

[c] Department of Mechanical Engineering , University of Western Macedonia, Greece

[d] Just Transition Institute Greece, Strategic Planning, Greece

Abstract

This paper presents a collaborative initiative between the University of Western Macedonia, Greece, and the Hellenic Electricity Distribution Network Operator (HEDNO), focusing on enhancing the expertise of Distribution Network Operator personnel. The initiative is tailored to both newly recruited and existing employees, addressing the contemporary challenges in the electricity grid sector. Central to the program are the commissioning and integration of Renewable Energy Sources (RES) and energy storage units into the grid, grounding practices, and the mandatory legal certification of personnel as electrotechnicians and safety technicians. This effort represents a strategic response to the dynamic and evolving demands of the energy industry, aiming to equip the workforce with advanced skills essential for the efficient operation and management of the modern electricity grid. The paper will detail the structure and content of the training program, its implementation strategies, and the anticipated impact on the proficiency and readiness of personnel in the face of rapidly advancing grid technologies.

Keywords: Renewable Energy Sources; Energy storage upskilling; Certified upskilling; Energy transition; Health & Safety.

How to cite: Boutsiadis,E.; Koulierakis, K.; Tsiamitros,D.; Stimoniaris,D.; Kollatou,T.; Krestou, A. and Karamarkos, K. (2024) Collaborative Reskilling: The Partnership of Hellenic Electricity Distribution Network Operator and University of West Macedonia in Advancing Smart Electricity Grids. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 421-429. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In response to the escalating energy demands and heightened environmental concerns of our era, the Hellenic Electricity Distribution Network Operator (HEDNO) has embarked on a groundbreaking partnership with the University of Western Macedonia, a move essential for the advancement of smart electricity grid technology. This collaboration, strategically positioned against the backdrop of a global shift towards renewable energy and sustainable practices, aims to address the intricate challenges facing modern electricity grids, such as the integration of renewable energy sources, enhancing grid reliability, and increasing consumer engagement in energy management. These challenges are crucial to the successful evolution of smarter grid systems as mentioned by many authors (Lucas, Pinnington and Cabeza,2018), (Kimuli et. al, 2017), (Malamatenios, 2016) and (Apostolopoulos et.al, 2023).

The partnership between HEDNO and the University of Western Macedonia is not just about enhancing the efficiency of Greece's energy distribution but also to contribute significantly to the global discourse on smart grid technology. This paper will explore the collaborative efforts of these two entities, their adopted methodologies, achievements, and the potential implications for future energy distribution systems. The initiative highlights the synergistic potential of industry-academia collaborations in technological advancement, especially in the smart electricity grids domain.

This initiative is guided by European and national laws that require Distribution Network Operators to ensure their staff are certified in safety and electrotechnician skills, including obtaining a B' class license. As the electricity grid evolves, incorporating Renewable Energy Sources, energy storage, and smart grid technologies, it becomes essential for Distribution Network Operators to update and improve the skills of their workforce. This need for retraining or upskilling applies even to experienced grid professionals.

The region of Western Macedonia was until recently the "Energy Heart" of Greece, since over 65 % of the electricity was produced in the region by coal-fired plants. Therefore, the Distribution Network operator was already operating one of its two training centers in the region (Florina city). After the energy transition of the country to Renewables, most of the Renewable Energy Units were established in the region to counterbalance the shut-down of the coal-fired plants. So the region was the most experienced in the connection of Renewables to the electricity grid and it was the first that faced the accompanying problems. Consequently, Western Macedonia was a natural choice for HEDNO's partnership in tackling the smart grid challenge.

The training programmes developed through this partnership were aimed at different groups: engineers involved in the connection and commissioning of renewable energy sources and energy storage units to the electricity grid, engineers wishing to become certified

2024, Editorial Universitat Politècnica de València BY-NC-SA

safety engineers for the distribution network operator, and technical staff wishing to obtain certification and a Class B licence as an electrical engineer. The following section provides a comprehensive overview of the training implementation, including the core training courses, their unique characteristics, organisational considerations, involvement of technical staff and trainers, challenges faced, and methods for evaluating and expanding the training initiative.

2. Main activities and syllabus

The courses conducted under the collaborative effort between the University of Western Macedonia and HEDNO encompassed a diverse range of activities, meticulously designed to equip participants with the requisite knowledge and practical skills. These activities were structured to cater to the unique requirements of each course and ensure comprehensive learning. Here, we delve into the core activities that enriched the learning experience:

One of the primary courses offered focused on training personnel for Electrotechnicians Class B Certification and was versatile, covering critical areas such as electrical currents (both DC and AC), electrical machines, information technology skills, grid protection, and an in-depth exploration of Renewable Energy Sources (solar and wind) along with electronics. This comprehensive curriculum was carefully designed to prepare participants for the demanding field of electrotechnics.

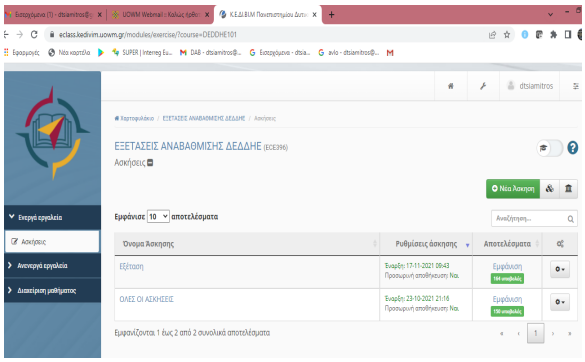
In the RES and Grounding section, the course covered more than just theory. It looked at practical skills such as how to connect RES (solar, wind, biomass, hydrogen and energy storage systems) to the grid and how to do proper earthing. The course was divided into five different parts, each focusing on a different type of RES. Trainees learned the technical details of connecting to the grid, followed standards such as VDE0126-1, and tackled key issues such as grounding, protection and pre-connection testing.

For the safety technicians, the training was all about maintaining a safe workplace. This included learning about self-protection, the responsibilities of safety engineers, how to create safety plans and how to use safety data sheets. The aim was to ensure that the technicians could keep themselves and their colleagues safe.

All the above have a common characteristic: They should be attended by electrical or mechanical engineers. A mix of teaching methods was used for the course. This included classroom theory, study materials in both print and electronic forms, an online platform (Fig.1) for learning at your own pace, hands-on labs (Fig.2), trips to actual work sites, and real-life procedures for setting up equipment. This mix of theory and practice made sure that everyone got a full understanding of the topics. This training shows the dedication of both the University of Western Macedonia and HEDNO to offer thorough and relevant education in the electrical field.

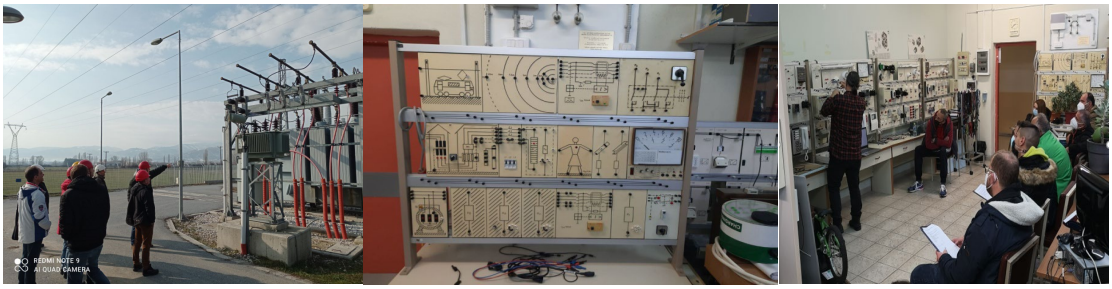
BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Asynchonous education web-platform



Source: Author

Fig. 2 – Lab and on-site education



Source: Author

2.1 Organization aspects

With the renewable energy sector booming as the world turns to sustainable sources, there's been a necessity to reevaluate the required job skills in this field, a point highlighted in Arcelay et. Al (2021). This led to a training initiative, through the collaboration between the University of Western Macedonia and HEDNO, that required careful planning and detailed coordination.

The initial action involved setting up contractual agreements with HEDNO. Two distinct contracts were formulated, each designed for separate training stages: initially, the Memorandum of Understanding, followed by the agreement between UoWM and the spinoff company INNORA for organizing a postgraduate course. The preparation of training materials was a crucial phase. This involved creating educational content in both PDF and PowerPoint formats, a collaborative task to ensure that the materials were effective and met the specific needs of the trainees.

Another important aspect was the development of an asynchronous web platform for learning. This platform, a joint creation of the University's VET department and UoWM, served as a central repository for educational resources and examination modules.

In terms of human resources coordination, there was a concerted effort with HEDNO's Human Resources and Education department. This collaboration facilitated the distribution of course invitations, scheduling, and managing logistical aspects.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The selection of suitable training venues involved negotiations with the university's vocational training department, usually using the university's classrooms in Kozani or HEDNO's training centre in Florina.

Tracking enrollment and attendance was integral to the effectiveness of the programme. This process required seamless registration of trainees on the VET platform, monitoring of e-presence and issuance of certificates of attendance, which required efficient coordination between the University and HEDNO.

The distribution of materials included not only printing course materials but also distributing electronic resources to participants, to enhance the learning experience.

Catering services were also arranged to ensure a comfortable learning environment for the trainees.

In addition, access to laboratory facilities was essential for the practical aspects of the training. This involved facilitating access to university laboratories or transferring necessary equipment to HEDNO's training centre. Field training visits were also organised to provide real and practical learning experiences. This involved coordinating logistics such as transport and liaising with site managers to ensure an effective learning environment.

Finally, the certification process, a critical final stage, involved working with certification bodies such as ACTA and TUV Austria. This involved organising a certification scheme and testing procedures to ensure that the trainees' skills were recognised according to industry standards. ACTA and TUVAustria submitted a study program per seminar and at least 100 multiple answers questions.

2.2 Involved technical staff and educators, the risks and encountered difficulties

The successful implementation of our training initiatives was made possible by the combined efforts of several institutions and dedicated individuals. Among the key contributors were

- HEDNO engineers and staff (five people): A team of five HEDNO engineers and staff actively participated, bringing their invaluable industry knowledge and experience to the training programmes.
- University professors and technical staff (eight people): Eight professors and technical staff from the university played a crucial role in delivering high quality educational content and ensuring that the courses met rigorous academic standards.
- University Vocational Training Centre (two members): Two members of the University's VET Centre were instrumental in facilitating the educational process and ensuring seamless access to training resources and platforms.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- UoWM spin-off company INNORA: INNORA, the spin-off company of the University of Western Macedonia, contributed innovative solutions and expertise to enhance the training initiatives.

While the combined efforts of these institutions and individuals produced remarkable results, it's important to acknowledge a significant challenge faced in delivering the training programmes. The most significant risk is the lack of availability of the personnel for training. This means that it is difficult to program their attendance to the seminars, since working on the electricity grid implies urgent situations that someone cannot predict (e.g.faults on the lines due to severe weather). To overcome these obstacles, it was necessary to plan and react flexibly to the dynamic nature of the industry and its operating needs.

3. Assessment and scale-up of the whole training effort

In order to measure the effectiveness and impact of our extensive training programmes, a comprehensive evaluation process has been put in place. As a first step, the trainees were asked to provide anonymous feedback by means of evaluation forms that were provided by both the University and HEDNO. All participants filled in the evaluation forms. These forms used a scoring system from 1 to 5, with all types of evaluations consistently above the commendable score of 4. This shared feedback shows that the training programmes were very successful.

The second step was external examination and certification, achieved through independent validation. All trainees underwent examinations conducted by independent institutions, including the Ministry of Development and the National Assurance System. The high pass rate of over 90% shows that the training was effective in preparing individuals for the challenges of their roles.

Finally, an overview of the impact of the outcomes. These training programmes have led to some major achievements:

-Successfully certified approximately 180 individuals for the Class B electrician exams.

-Upgrading of 112 engineers with updated certification skills, increasing their knowledge and competence.

-15 individuals certified as HEDNO Safety Technicians, further reinforcing the electrical industry's commitment to safety.

These assessments not only validate the quality of the training programmes. They also underline their real impact on individuals and the industry. Our aim is to ensure that our future efforts are even more successful and help raise the bar for professional development in the electrical industry.

2024, Editorial Universitat Politècnica de València BY-NC-SA

3.1 Assessment of Key Performance Indicators

We use a number of key performance indicators (KPIs) to assess the effectiveness and overall success of our extensive training programmes. These KPIs are essential to provide us with objective evidence of the impact and success of our training initiatives (Varouchas, Sicilia and Sánchez-Alonso, 2018). The following KPIs were used to assess the success of the training courses:

The first is the request for repetition of the seminars by HEDNO: This has already been achieved, as HEDNO plans to repeat the training courses on RES and safety in Athens from February 2024 to December 2024.

The second is the evaluation of the training courses by the trainees: The average score is 4.2 out of 5 (highest score).

The third key performance indicator is the increase in the HEDNO health and safety index. This is shown by the number of personnel certified in health and safety issues and in accident information. This index still needs to be improved.

The final KPI is the increase in the number of seminars: A post-graduate professional course is about to start in February 2024, which includes in its curriculum all the training issues mentioned above. This post-graduate course (level 7 course) has already been certified by the National Higher Education Authority of Greece with grade A and is now the most important indicator that all the above training courses have been fully successful.

4. Replication in Other Countries

When replicating this GP, there are some key challenges that should be addressed in order to design successful training programs. Adaptation of training material to local industry needs and alignment to national legal requirements are two of them. The existing skills level is also a factor that should be strongly considered during the courses development. The establishment of strong collaboration among the parties involved for the development of training material, the design of flexible training modules and the elaboration of a blended learning approach combining theory, practical exercises, and online resources are factors that also should be weighed when designing the upskilling courses. Last but not least, the availability of technical expertise (trained trainers) is also crucial.

Tailoring the program to address these specific needs ensures that the upskilling GP could be both relevant and effective.

The rate of success of the program is measured by the fact that the trainees are making questions during the course and after the seminar they are more confident on dealing with a very important field , such as the commissioning of RES.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

5. Conclusions

In conclusion, the teamwork between the University of Western Macedonia (UoWM), the Hellenic Distribution Network Operator (HEDNO) and other key stakeholders has led to great achievements in training for the electrical sector. Our well-planned and executed training has not only provided professionals with the skills and certifications they need for the changing industry, but has also set a high bar for what training programmes should be.

Thanks to the hard work of a diverse group of engineers, teachers, technicians and other dedicated people, our courses have really hit the mark in meeting the ever-changing needs of the electricity network sector. The evaluation of these training programmes, which includes student evaluations, external audits and measurable outcomes, has consistently demonstrated their effectiveness and impact.

In addition, our ability to adapt to unexpected challenges, such as staff availability during urgent network situations, demonstrates our commitment to excellence in the face of industry realities.

As we reflect on the achievements of these initiatives, we remain committed to continuous improvement and expansion. The journey to improve the skills and safety measures within the electrical sector continues, driven by the collaborative spirit and commitment to excellence demonstrated throughout this endeavour. With each successful training course, we move one step closer to a safer, more competent and innovative electrical industry landscape.

Acknowledgements

The HEDNO and the UoWM have signed a Memorandum of Understanding on May 2023 with main purpose to enhance education and research cooperations. Thus, all the above training courses are fully funded by the HEDNO. Moreover, the new law framework in Greece encourages and allows professional postgraduate courses between universities and enterprises. Therefore, the contract between the University and HEDNO for the professional postgraduate course is valid for 2 years, with a perspective for 5 more years, according to the new law and has a secured funding for this duration.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Apostolopoulos, N.; Kakouris, A.; Liargovas, P.; Borisov, P.; Radev, T.; Apostolopoulos, S.; Daskou, S.; Anastasopoulou (2023). E.E. Just Transition Policies, Power Plant Workers and Green Entrepreneurs in Greece, Cyprus and Bulgaria: Can Education and Retraining Meet the Challenge? Sustainability 2023, 15, 16307. https://doi.org/10.3390/su152316307

Arcelay, I.; Goti, A.; Oyarbide-Zubillaga, A.; Akyazi, T.; Alberdi, E.; Garcia-Bringas, P. (2021). Definition of the Future Skills Needs of Job Profiles in the Renewable Energy Sector. Energies, 2609. https://doi.org/10.3390/en14092609

Hugo Lucas, Stephanie Pinnington, Luisa F. Cabeza. (2018). Education and training gaps in the renewable energy sector, Solar Energy, Volume 173,Pages 449-455.

Kimuli, D. ., Nabaterega, R. ., Banadda, N. ., Kabenge, I. ., Ekwamu, A. ., & Nampala, P. . (2017). Advanced Education and Training Programs to Support Renewable Energy Investment in Africa. International Journal of Education and Practice, 5(1), 8–15. https://doi.org/10.18488/journal.61/2017.5.1/61.1.8.15

Malamatenios Ch. (2016). Renewable energy sources: Jobs created, skills required (and identified gaps), education and training, Renew. Energy Environ. Sustain.,Volume 1, p. 6, https://doi.org/10.1051/rees/2016038

Varouchas, E.; Sicilia, M.-Á.; Sánchez-Alonso, S., (2018). Academics' Perceptions on Quality in Higher Education Shaping Key Performance Indicators. Sustainability 2018, 10, 4752. https://doi.org/10.3390/su10124752

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024
https://doi.org/10.4995/SEED2024.2024.xxxxx

European Initiatives for Professional Excellence in Fossil Free Energy Production

Athina Krestou[a], Alkiviadis Tsamis[a,b], Stefanos Gerardis[a], Stergios Maropoulos[a], Adam Stimoniaris[c], Fokion Papathanasiou[d], Konstantinos Karamarkos[a,e], Sofia Papanikolaou[a], Andreas Maropoulos[a] and Fotios Tsampouris[a]

[a] Department of Mechanical Engineering, University of Western Macedonia,Greece
[b] School of Engineering- College of Science and Engineering, University of Leicester, UK
[c]Department of Chemical Engineering, University of Western Macedonia, Greece
[d]Department of Agriculture, University of Western Macedonia, Greece
[e] Just Transition Institute Greece, Strategic Planning, Greece

Abstract

The current work outlines European Initiatives focused on achieving Professional Excellence in Fossil-Free Energy Production. It delves into their objectives, methodologies, and key outcomes, with the primary aim of showcasing how these initiatives facilitate the transition to sustainable energy in Europe by creating a skilled workforce. The document highlights various programs, training modules, and collaborative endeavors that play a significant role in enhancing professional expertise in fossil-free energy. Additionally, it provides case studies as evidence of the effectiveness of these European Initiatives in addressing skill gaps within the energy sector. Finally, the paper offers recommendations for further strengthening and expanding these initiatives to align with the ever-evolving requirements of a sustainable energy future.

Keywords: sustainable training; sustainable education; RES; EU initiatives.

How to cite: Krestou,A.; Tsamis,A.; Gerardis, S.; Maropoulos, S.;Stimoniaris, A.; Papathanasiou, F.; Karamarkos, K.; Papanikolaou, S.; Maropoulos, A. and Tsampouris, F. (2024) European Initiatives for Professional Excellence in Fossil Free Energy Production. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 430-438. https://doi.org/10.4995/SEED2024.2024.xxxxx

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Under the European Green Deal (European Commission, 2019), the EU has set a target to become a climate-neutral entity by 2050. This means that it will be transformed to an economy with effectively zero net greenhouse gas emissions. Towards this end, a marked objective was outlined in November 2023, when the EU committed to reduce greenhouse gas emissions by a minimum of 55% by the year 2030. To reach this milestone, EU should increase the use of renewable energy and at the same time enhance the energy efficiency.

This shift necessitates a significant transformation in the energy sector, moving away from reliance on fossil fuels towards the adoption of renewable energy sources. Accordingly, various technical, managerial, and operational challenges would be needed, particularly in the realm of fossil-free energy production arise. To address these challenges, the EU has launched several initiatives in order to reinforce the European workforce, both in areas directly and indirectly impacted by this energy transition. These initiatives promote the Professional Excellence in Fossil-Free Energy Production and represent a strategic approach to urgently address the need for reskilling and upskilling of the workforce.

Since it is essential to equip the corresponding personnel with the necessary knowledge and skills for implementing sustainable energy practices (Blazquez-Soriano and Ramos-Sandoval, 2022), these initiatives include programs ranging from specialized training modules to collaborative research projects. These programs are designed to foster professional excellence in key areas of the renewable energy sector. In the current paper, key European initiatives promoting professional excellence in fossil-free energy production are presented, along with their impact on the development of sustainable energy practices. Selected case studies are also documented, revealing the role of education and training in cultivating a skilled workforce for the renewable energy sector.

2. European Initiatives and Policies

2.1 The European Green Deal

The European Green Deal (European Commission, 2019) is a policy initiative that outlines a strategic framework for the European Union's transition to a sustainable and resilient energy future. To enhance the necessary skills for the fossil-free energy production, this policy encompasses several key initiatives, such as the: i) establishment of **Net-Zero Industry Academies** to develop up-skilling and re-skilling training programs (a Renewable Energy Skills partnership was formed on September 2023 following this initiative), ii) adoption of a **"Skills-first"** approach combining skills recognition with qualifications, iii) facilitation of non-EU member states' access to the EU labor market priority sectors, and iv) development of measures to foster and align public and private funding for skills development.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

In addition to green skills, EU is also focusing on enhancing **digital skills**. However, the lack of basic digital skills (Alcaide et al, 2020) is hindering the EU's ability to fully exploit new opportunities in the clean energy sector (European Commission, 2019). To address this challenge and stimulate growth in the energy sector, the European Green Deal sets a goal of creating 2.5 million new jobs within the EU by 2030. Upskilling is recognized as crucial for this transformation. The **European Pillar of Social Rights Action Plan** sets an ambitious target: by 2030, at least 60% of adults should engage in learning activities annually, a significant increase from 37% in 2016 (EC, 2020).

2.2 EU Skills Agenda

The **EU Skills Agenda** includes ambitious targets to upskill and reskill 120 million adults annually, which means that 30% of low-qualified adults would be participating in learning at least once a year, or around 14 million adults every year, and that the number of adults with basic digital skills would increase by a third. As part of these efforts, the European Union has earmarked sizeable funds to support worker training. While the **European Social Fund Plus (ESF+)**, which is dedicated to improving employment opportunities in the European Union, remains the main source of financing, national recovery and resilience funding plans also include reskilling and upskilling activities. Moreover, the European Union has set up a €19.3 billion **Just Transition Fund**, aimed at mitigating socio-economic impacts stemming from energy transitions, which is also expected to support skills training (IEA, 2022).

A flagship action of the European Skills Agenda is the **Pact for Skills**. Through this Action, public and private organizations collaborate in upskilling and reskilling. Emphasis is given in the lifelong learning and establishment of strong skills partnerships, as well as monitoring skills supply and demand (IEA, 2022). Examples of successful skilling initiatives by Pact members across Europe, include: ***Femxa Formación in Spain*** (integrated over 60 migrant women into the labor markets of Latvia and Spain through training programs), ***The Wheel organisation in Ireland*** (created a Leadership Academy to enhance skills in the social economy sector), ***The Municipality of Lisbon*** ("Digital Skills Passport" for digital skill micro-credentials), ***The Emphasys Centre in Cyprus*** (provides skill development opportunities for vulnerable groups by making their learning hub available during off-hours), ***The European Federation of Tourist Guide Associations*** (designed masterclasses to upskill trainers, focusing on inclusion and digital skills).

2.3 European Climate Pact

With this pact, the engagement of citizens in climate action is envisaged. It was launched in December 2020, and encourages the sharing of knowledge, the climate change and the development, implementation, and scaling up of climate solutions. "Green skills" are prioritized within the pact and educational institutions are supported in enhancing these skills

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

through dedicated programs. The collaboration with stakeholders involved in the Pact for skills is also promoted aiming to disseminate results through initiatives, such as the European Vocational Skills Week and Erasmus+ projects (EU, 2020).

2.4 Cohesion Policy

Energy transition towards a greener and low-carbon Europe is supported by the EU's €392 billion policy for 2021-2027 through various funds. The **European Regional Development Fund (ERDF)** backs initiatives in energy efficiency, renewable energy, and sustainable transport. The **Cohesion Fund**, available to 15 Member States, invests in environmental and transport sectors, particularly renewable energy. Successful case studies of projects related to reskilling/upskilling in the renewable energy sector are presented in paragraph 5 (5.1-5.3) . The **European Social Fund Plus (ESF+)** emphasizes employment, social inclusion, and skill development, aiding the energy sector's workforce transition and social integration efforts. The **European Globalisation Adjustment Fund for Displaced Workers (EGF)** is an instrument designed to provide particular assistance to individuals who lost their jobs due to the shift to the a low-carbon economy. The Fund promotes the offering of career guidance, the support of education and training initiatives, and facilitates entrepreneurship and business creation. The fund has an annual budget of €210 million for the period from 2021 to 2027 (European Commission, 2021).

2.5 Renovation Wave

This policy tool, launched in October 2020, aims to double renovation rates by 2030. With the achievement of this goal it is expected that up to 160,000 green jobs will be generated in the construction industry. With this initiative, the incorporation of green and circular skills into current job roles are emphasized.The development of new professional profiles, such as deep renovation specialists is also encouraged. Last but not least, this policy tool highlights the importance of inclusivity and gender equality, along with the engagement of social partners, in order to improve workforce skills (Interreg Europe,2021).

3. Collaborative Frameworks and Partnerships

3.1 European Cooperation in Science and Technology (COST)

The COST framework is designed to enhance the collaboration among European researchers in fossil-free energy, giving emphasis to network building, sharing of research and exchange of knowledge. Scientists across Europe can connect to each other and exchange information on the latest in energy production, as well as design and implement collaborative projects, workshops, and conferences, enabling the sharing of scientific knowledge and best practices. Researcher mobility and data sharing are also promoted through this framework, leading to an enhancement of the research efficiency. Only for the period 2023-2027, 31 networks

BY-NC-SA 2024, Editorial Universitat Politècnica de València

related to energy have been established (COST, 2023). Thus, a capacity building in the field of energy can be evolved. Since 1971, COST receives EU funding under the various Research and Innovation Framework Programmes, such as Horizon 2020 and Horizon Europe (European Commission, 2019).

3.2 Joint Programming Platforms

Joint Programming Platforms (JPPs) in the EU enhance sustainable energy research by coordinating member states' efforts. They streamline national research strategies, pool resources, and encourage joint projects, targeting key energy challenges. JPPs efficiently utilize funds, avoiding duplication and fostering impactful, wide-ranging research. They play a crucial role in shaping policies, fostering innovation ecosystems, and building research capacity. This collective approach not only drives sustainable energy technology development, but also nurtures a skilled workforce to meet future challenges in the sector (International Energy Agency, 2022).

4. Research,Education and Training

4.1 Horizon Europe

Horizon Europe, is the EU's flagship research and innovation program, that, particularly in the renewable energy sector, plays a crucial role in advancing knowledge and technology. Funding opportunities under this program, aiming to promote excellence in the field, can be found under the **Marie Skłodowska-Curie Actions (MSCA)** and the **Horizon Coordination and Support Actions - European Excellence Initiative (Horizon CSA-EEI)**.

The MSCA aims to foster a competitive European research landscape, focusing on interdisciplinary work, innovation, and training new researchers, and continues to play a key role in Horizon Europe for scientific advancement and collaboration. As such, the Action promotes advanced research training and facilitates the researcher development through mobility, international cooperation, and various training initiatives, including Individual Fellowships, Innovative Training Networks, Staff Exchange, and Co-funding programs.

On the other hand, the Horizon CSA- EEI builds on the broadening of collaboration among the higher education institutes (HEIs), fostering scientific excellence and innovation. This initiative focuses on the modernization of research careers and the acceleration of the digital transition in Research & Innovation towards a cultivation of a culture of excellence in science across HEIs (European Commission, 2020).

4.2 Erasmus+ Program

The Erasmus+ Program, targets education, training, youth, and sports giving emphasis to the development of a workforce with skills related to the renewable energy sector. International

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

mobility, joint Master's programs, vocational education partnerships, and alignment of education with industry needs are promoted through the program. It contributes to the enhancement of higher education capacity building, encourages innovation and entrepreneurship, and improves language and intercultural competences, which are essential in the global renewable energy market. Moreover, the program focuses on professional development for educators (train-the-trainer actions), ensuring up-to-date teaching in renewable energy technologies (International Energy Agency, 2022).

4.3 Vocational Training and Internship

Vocational training and Internship play a vital role in equipping individuals with the necessary skills for careers in fossil-free energy production. These skills are gained through practical experience and industry-relevant education, and are essential for a career progression. Vocational training and Internships can therefore contribute to the strong demand for reskilling and upskilling of the workforce employed in the energy sector, considering the continuous changes the sector undergoes.

It is widely appreciated that a skilled workforce can contribute to the development, operation, and maintenance of renewable energy technologies (Zuhal et al, 2010). For this reason, the European Union promotes the creation of Centers of Vocational Excellence (CoVEs) through funding from the Erasmus+ program. CoVEs are networks that include vocational education and training (VET) providers, policymakers, and companies. These networks are centered around specific topics and can have diverse roles in policy-making (ETF, 2020).

5. Case Studies

In the following section, successful outcomes and lessons learned from specific projects or collaborations within the European initiatives for professional excellence in fossil-free energy production are highlighted. The Case Studies presented, show that training programs can play a critical role in equipping the workforce with skills necessary for the energy transition.

5.1 CROSKILLS

The Croskills project, started in Croatia in 2012 and was related to the development of curricula in the construction sector. Trainees acquired skills related to energy efficiency of buildings and renewable energy systems and measures so they could deliver building renovations with high-energy performance. Additionally to the creation of training modules, the program included train-the-trainer activities and the development of certification schemes. 18 training modules for six construction professions were established while 11 training centers were created. Moreover, 90 trainers were accredited and 330 certifications were issued. The project enhanced the appeal of targeted professions and set a successful

BY-NC-SA 2024, Editorial Universitat Politècnica de València

example for regional initiatives aligned with EU energy and climate goals for 2030.The EU's 'Build Up Skills' initiative, through the CROSKILLS project, addressed the need for systematic training and certification in energy-efficient construction (Interreg Europe, 2021).

5.2 WE Qualify

The WE Qualify project, under the Intelligent Energy Europe and Build Up Skills Initiatives in Cyprus, focused on improving vocational training in construction-related technical roles, particularly in energy-saving and renewable energy systems. The outcomes of the project include the development of three training modules for 92 specialized installers, and the upskilling and certification of 76 professionals. Through this program, the importance of tailored training programs based on gap analysis in order to enhance skills crucial for the energy transition and job creation in Europe was highlighted (Interreg Europe, 2021).

5.3 REDU

REDU is a major vocational education provider owned and funded by six municipalities in Lapland, Finland. It operates an integrated district heating plant that is used for bioenergy production training, including activities from harvesting to refining biomass for energy production. This approach, although designed for regional energy needs and according to the Finish legal context, serves as an exemplary model for vocational training in renewable energy across Europe, as it is tailored to address regional energy needs and legal constraints while efficiently developing skills for the workforce (Interreg Europe, 2021).

5.4 "European Master in Renewable Energy" and "European Master in Sustainable Energy Management"

The European Master in Renewable Energy comprises a consortium of universities, and targets graduates with an Engineering or Science Bachelor's degree. This MSc program was launched in 2002, and since then it has become a major provider of postgraduate education in renewable energy technology in Europe, with a number of 15 students per year participating in the courses. The program is focused on the technical aspects and implementation of renewable energy technologies and is conducted in multiple languages.

A network of nine European universities and research centers runs a second Master's program, the European Master in Sustainable Energy Management (SESyM), that was launched in 2015. To meet industry and student needs, the SESyM blends technical and business skills, allowing students to choose from four universities in different countries.

Both of the aforementioned MSc programs are funded by the EUREC and have a global reach, with students from over 30 countries participating in the 2020 intake. Graduates join the EUREC Alumni Network, comprising more than 800 professionals who share knowledge and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

job opportunities, highlighting the success and impact of these pioneering programs in the renewable energy education landscape.

6. Conclusion

European initiatives are driving professional excellence in fossil-free energy production, essential for the transition to sustainable energy sources. Collaborative efforts like COST, Joint Programming Platforms, and Erasmus+ highlight collective commitment to addressing transition challenges and seizing renewable energy opportunities. Key takeaways include: (i) Collaboration for Progress, (ii) Capacity Building and Skill Development, (iii) Alignment with Industry Dynamics, (iv) Global Perspective and Innovation, and (v) Continuous Learning and Adaptation.

The importance of these initiatives in the creation of a skilled workforce was highlighted by the case studies presented. They have effectively enhanced vocational training, targeted skills development in energy efficiency, renewable energy technologies, and contributed to the workforce's ability to meet emerging energy and climate goals. Notably, these projects align with EU directives and local needs, demonstrating a profound impact on job creation and sustainable development.

To promote professional excellence (Lowman, 2022, and Olsonet al, 2021), future efforts should focus on: (i) Strengthening the Innovation Ecosystem, (ii) Integrating Emerging Technologies, (iii) Supporting Policies and Standardization, (iv) Promoting Circular Economy Practices, and (v) Enhancing Digitalization Training. Proactive approaches are essential to address emerging challenges and seize new opportunities, ensuring a skilled workforce leads the way to a cleaner, greener energy landscape.

Acknowledgements

The SEED project, which has been funded by the European Union's EACEA.A - Erasmus+, EU Solidarity Corps under the Grant Agreement No 101056147, is acknowledged for the development of this research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Alcaide González, M. Á., De La Poza Plaza, E., & Guadalajara Olmeda, N. (2020). The impact of corporate social responsibility transparency on the financial performance, brand value, and sustainability level of IT companies. *Corporate Social Responsibility and Environmental Management*, 27(2), 642-654. https://doi.org/10.1002/csr.1829

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Blazquez-Soriano, A., & Ramos-Sandoval, R. (2022). Information transfer as a tool to improve the resilience of farmers against the effects of climate change: the case of the Peruvian National Agrarian Innovation System. *Agricultural Systems*, *200*, 103431. https://doi.org/10.1016/j.agsy.2022.103431

European Commission (2019). Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions -The European Green Deal, Brussels, 11.12.2019, COM(2019) 640 final.

COST Actions Booklet 2023-2027

European Commission (2020). Shaping Europe's Digital Future (https://digital-strategy.ec.europa.eu/en/policies/digital-skills)

European Commission (2021). Cohesion Policy (https://ec.europa.eu/regional_policy/policy/what/investment-policy_en)

European Union (2020). European Climate Pact (https://climate-pact.europa.eu/about/about-pact_en)

European Training Foundation (2020). Centres of Vocational Excellence- An engine for vocational education and training development. AN INTERNATIONAL STUDY

Lowman, R. L. (2022). Career assessment: Integrating interests, abilities, and personality. American Psychological Association. https://doi.org/10.1037/0000254-000

Interreg Europe (2021). A Policy Brief from the Policy Learning Platform on Low-carbon economy.

International Energy Agency (2022). Skills Development and Inclusivity for Clean Energy Transitions.

Olson, B.V., McGuire, C., Crawford, A. (2021). Improving the Quality of Work Life: An Interdisciplinary Lens into the Worker Experience. In: Dhiman, S.K. (eds) The Palgrave Handbook of Workplace Well-Being. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-30025-8_3

Zuhal Polat, Selçuk Uzmanoğlu, Nuriye Çevik İşgören, Ayşe Çınar, Necla Tektaş, Bekir Oral, Gülhan Büyükpehlivan, Leyla Ulusman, Demet Öznaz (2010). Internship education analysis of vocational school students, Procedia - Social and Behavioral Sciences Volume 2, Issue 2, 2010, Pages 3452-3456 . https://doi.org/10.1016/j.sbspro.2010.03.533

2024, Editorial Universitat Politècnica de València BY-NC-SA

Techno-Economic Evaluation of Flexible Technologies for Renewable Energy Communities

Álvaro Manso-Burgos[a], David Ribó-Pérez[a], Isabel Aparisi-Cerdá[b] and Tomás Gómez-Navarro[a]

[a] Institute for Energy Engineering, Universitat Politècnica de València, Camino de Vera, s/n 46022 València, Spain

[b] INGENIO (CSIC-UPV), Universitat Politècnica de València, Camino de Vera, s/n 46022 València, Spain

Abstract

Renewable energy communities are essential for the Energy Transition as they offer a means to restructure energy systems by harnessing the energy and allowing citizens to participate actively in the change. By integrating flexible technologies like storage, electric mobility, and climatisation, RECs can unlock renewable power's full potential. However, the economic performance of these combinations has not yet been evaluated. In this work, we assess the impact of flexibility technologies on a REC's financial performance to determine the best scenarios to invest in these technologies. The case study is located in València, a compact Mediterranean city in Spain, and consists of a solar photovoltaic installation for power generation backed by the national grid. The energy community also integrates a collective storage system, various charging stations for electric vehicles and air-source heat pumps in each household. This work performs a techno-economic assessment of the impact of ten economic and technical variables. These results aim to accelerate the electrification of Mediterranean cities by helping promoters design more energy communities with greater economic and environmental benefits and policymakers make better use of the subsidies.

Keywords: energy community; flexibility technologies; climate neutral cities; sensibility analysis; decarbonisation strategies.

How to cite: Manso-Burgos, A., Ribó-Pérez, D., Aparisi-Cerdá, I. and Gómez-Navarro, T. (2024) Techno-Economic Evaluation of Flexible Technologies for Renewable Energy Communities. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 439-446. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The need for a joint and comprehensive effort to reduce carbon emissions worldwide has become increasingly urgent as the global climate crisis worsens. Urban centres are the primary drivers of economic activity and have become the main focus of effective decarbonisation strategies (Lazaroiu & Putrus, 2023). Due to rapid urbanisation and the concentration of energy-intensive activities within cities, it is essential to decarbonise urban centres to address environmental concerns and achieve economic and social benefits (van Bommel & Höffken, 2021).

Renewable energy communities (RECs) are legal entities formed by natural persons, SMEs, or local authorities based on open and voluntary participation. The primary purpose of RECs is to achieve social, environmental, or economic benefits rather than financial gains. These communities can engage in various aspects of the energy value chain, including production, distribution, supply, consumption, and aggregation. In the European context, RECs are essential for the energy transition as they offer a means to "restructure energy systems by harnessing the energy and allowing citizens to participate actively in the change" (European Commission, n.d.). RECs have also been shown to promote a sustainable culture and accelerate the energy transition while providing citizens greater benefits from participating (Brummer, 2018). These RECs face a significant constraint due to renewable energy sources' uncertain and variable nature. We study how battery energy storage, electric climatisation and the incorporation of EVs can mitigate this limitation.

Energy storage is critical to unlocking renewable power's full potential as it helps balance the variability in generation and increase the degree of self-consumption of renewable power. This increment in self-consumption reduces surplus feeding into the grid and demand for electricity from polluting plants. Energy storage allows individuals and communities access to electricity during outages or when there is no sun radiation and can help energy users mitigate the impact of electricity fluctuation. Besides, integrating storage in energy communities at a collective level is more cost-effective and energy-efficient than individual storage (Walker & Kwon, 2021). Thus, a Battery Energy Storage System (BESS) is included in the REC to evaluate its influence on REC's economic performance.

Electric Vehicles (EVs) will be vital elements in the future electric infrastructure and demand. Transport electrification is one of the European Union's strategies, aiming "to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition" with the REPowerEU Plan (European Commission, 2022) by raising Greenhouse Gas (GHG) emission standards for cars and vans. The goal is 100% GHG emissions reduction from new cars and vans in 2035 (European Commission, 2023). Recharging EVs can be an alternative to feeding surpluses to the grid, while the EVs can access cheaper recharging tariffs. At the same time,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

REC members will often own EVs while sharing the urban environment. Therefore, EVs are incorporated into the energy community to study which impact they could have.

The demand-side electrification scenario is completed by adopting high-efficiency Air-Source Heat Pumps (ASHPs) for heating and cooling generation. These systems maintain home comfort, replacing gas boilers or other inefficient or fossil-fuel-based technologies. In this work, the REC adopts a communal ASHP shared among the members of the REC, according to the proposal by Masip et al. (Masip et al., 2021). In addition, the case study allows for exploring its performance in southern Europe, a region with a balanced relevance of heating and cooling needs. This region has received little academic attention but may become critical due to the impacts of climate change (Palacios-Garcia et al., 2018; Prades-Gil et al., 2023).

In this work, we assess the impact of flexibility technologies on a REC's economic performance to determine the conditions for profitable investments and ways of operating a REC. The studied variables include the price and size of PV and battery systems and the cost of electricity and petrol. These factors are critical for energy communities' design because technology and resource prices fluctuate drastically. However, a research gap is identified because, to the best of the authors' knowledge, only Gallego-Castillo et al. (Gallego-Castillo et al., 2021) have recently made a sensitivity analysis about the impact of prices on decentralised power generation. They assess the effects of varying PV systems and battery storage costs under different regulatory scenarios.

For that, a mathematical model is used to simulate the operation of a REC placed in Valencia, a compact Mediterranean city in Spain, where climate change probably will lead to a cooling-dominated climate, as stated by Prades et al. (Prades-Gil et al., 2023). The energy community comprises residential households, various EV recharge points, a collective BESS and an ASHP in each household. Real hourly electricity consumption data is collected from their smart meters, and photovoltaic electricity generation is calculated based on actual stochastic data of sun radiation.

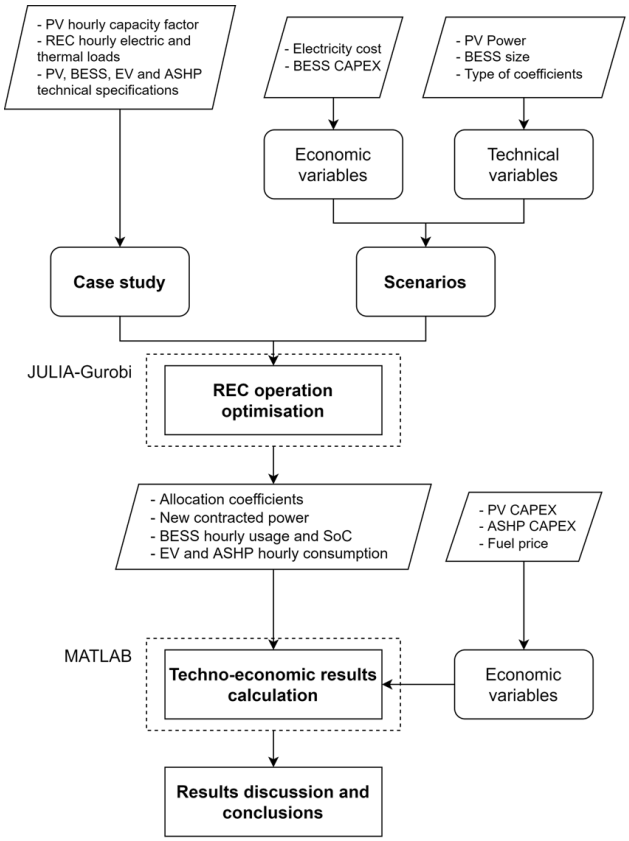
Sensibility analyses are performed on all the variables to capture their outlooks. Thus, profitability thresholds are identified for electrifying the heating and cooling system, integrating storage and mobility into a REC based on grid prices and battery costs on one side and grid and fuel prices and EV subsidies on the other. These results aim to accelerate the electrification of Mediterranean cities and the deployment of RECs by helping promoters design energy communities with larger economic benefits for their users and higher carbon emission reduction and policymakers to make better regulations and use of the subsidies.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Methods

Figure 1 shows the methodology for evaluating and analysing the relevant variables. First, we define the characteristics of the case study and the scenarios. The case study is determined from the location's climatic conditions that affect the solar capacity factors and the thermal demands, the users' electrical consumption and the selected equipment.

Figure 1. The methodology used to optimise REC's operation and evaluate the sensibility of different variables.



Source: Own elaboration

The scenarios are generated from the variables depicted in Table 1. We perform a sensibility assessment of these variables for the REC's profitability under three scenarios: current trend, best and worst case scenarios. These scenarios will allow us to expand the range of possible outcomes for the energy community and improve our evaluation of the sensibility of each variable.

For the simulation of the REC, we develop a linear optimisation model to determine the optimal energy-sharing coefficients that minimise users' energy bills. For that, we can use static, variable or dynamic allocation coefficients. The model provides each user's best hourly allocation coefficients, the contracted power according to users' consumption, and the optimal operation for BESS, EV chargers and ASHPs. Once we obtain these optimisation

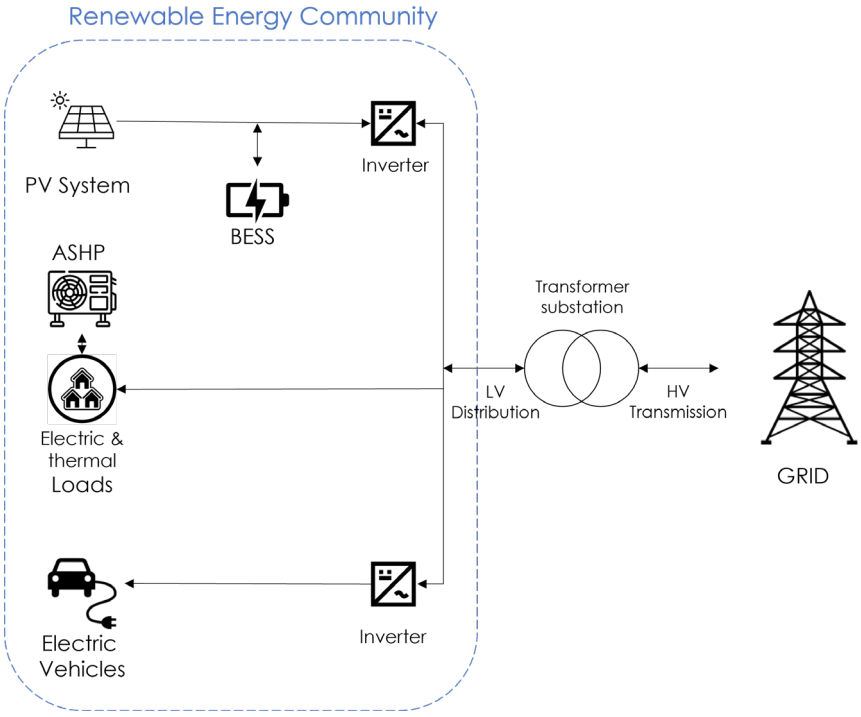
2024, Editorial Universitat Politècnica de València BY-NC-SA

results, we perform a techno-economic analysis to evaluate the influence of the relevant variables on the economic profitability of the REC. We get techno-economic KPIs for the performance of the REC with different PV system procurement costs, ASHP costs and fuel prices. Finally, these results are discussed to draw meaningful conclusions.

3. Case study

The subject of the case study is a REC installed in Valencia, a Mediterranean city in Spain. The REC mainly comprises the elements shown in Figure 2, which include electric and thermal loads from the dwellings, a PV installation, a collective BESS, EV chargers, ASHP in each household and the national electricity grid as the primary energy supply.

Figure 2. REC system diagram.



Source: Own elaboration

Table 1 displays the values of the eleven variables studied in this work used in each scenario. The current trend scenario corresponds to the values we believe are more likely for the coming years; hence, we expect most prices to decrease compared to the reference values according to the current market. The best-case scenario is one in which all trends are favourable for investing in the energy community, and, therefore, all the technology prices drop while grid electricity, natural gas, and fuel costs rise. Alternatively, the worst-case scenario for REC's profitability occurs when technology prices increase while energy vector prices decrease. Once the scenarios are defined, we obtain nine values for each variable to assess sensibility. These nine values are equidistant points between the two extreme values.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1. Current trend, best and worst scenarios for each variable's sensitivity assessment.

Variable	*Units*	*Current Trend*	*Best Case*	*Worst Case*
Coefficients	-	Variable	Dynamic	Static
PV P_{nom}	*kWp/hh.*	2.5	4.5	0.5
BESS capacity	*kWh*	100	250	12.5
EVs	*u.*	20	40	5
Grid price	*% over 2021*	75%	125%	25%
PV system CAPEX	*% over reference*	80%	40%	125%
BESS CAPEX	*% over reference*	80%	50%	105%
ASHP CAPEX	*% over reference*	75%	50%	100%
GN price	*€/kWh*	0.08	0.11	0.05
EV CAPEX	*% over reference*	90%	80%	100%
Fuel price	*€/L*	2.10	3.00	1.20

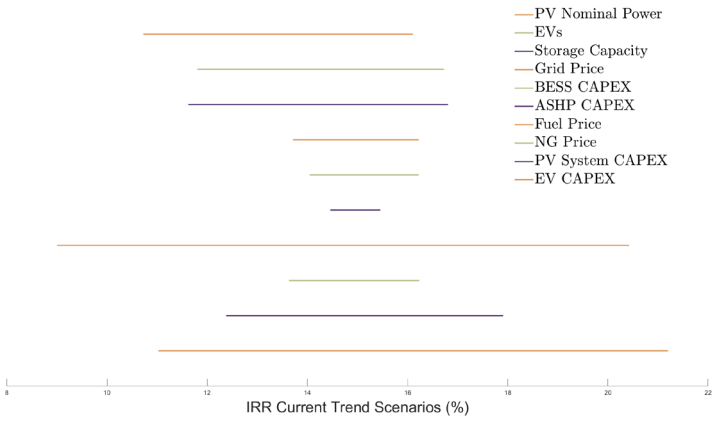
Source: Own elaboration

4. Results and insights

Figure 3 shows the Internal Return Rate (IRR) of the variable's sensibility assessment under the current trend scenario. The variables with spreader IRR values indicate which variables have more significant impacts on the financial outcome of the REC. In this case, the fuel and electric vehicle prices are the most critical variables. The reason behind this result is that the investment in EVs is very significant; hence, whether these vehicles are profitable is essential to the economic performance.

After those two variables, the three design variables prove their relevance and point to the importance of a good design to achieve the best economic outcomes.

Figure 3. IRR values for each variable under current trend values.



Source: Own elaboration

 BY-NC-SA

5. Conclusions

This study examined the economic viability of a Renewable Energy Community (REC) in Valencia, Spain, focusing on the integration of flexible technologies like battery storage, electric vehicles (EVs), and air-source heat pumps (ASHPs). Our research fills a critical gap by assessing the impact of various economic and technical variables on REC profitability, providing insights for stakeholders.

Key findings emphasize the crucial role of flexibility technologies in enhancing REC economic performance. Including a BESS demonstrate benefits in optimizing self-consumption and minimizing surplus electricity. Integrating EVs aligned with the REPowerEU Plan showcased the importance of considering electric mobility in REC planning. Adopting communal ASHPs for heating and cooling needs showed promise, contributing to decarbonizing heating systems in a Mediterranean climate.

Our linear optimisation model offered an agile and innovative tool for optimizing energy-sharing coefficients among REC members, balancing economic feasibility and sustainability. Sensitivity analyses highlighted profitability thresholds, guiding investment decisions and policy formulation. The study underscores the need for adaptive REC structures, considering fluctuating technology and resource prices.

In conclusion, this research provides practical guidance for promoting and regulating RECs, accelerating the electrification of Mediterranean cities. As global efforts intensify toward a greener future, our findings offer actionable information for shaping sustainable energy communities in urban settings.

Acknowledgements

This work was supported by a grant of the Cátedra de Transición Energética Urbana- funded by Ajuntament de València-Las Naves and Fundació València Clima i Energia; the RES4CITY project, financed by the European Union under Grant Agreement No. 101075582; and the PURPOSED project (PID2021-128822OB-I00) funded by Agencia Estatal de Investigacion of Spain.

We do appreciate all the support of Pr. Hatef Madani and his team at the Unit of Applied Thermodynamics and Refrigeration of KTH, Sweden, in revising and improving the MILP for this research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Brummer, V. (2018). Community energy – benefits and barriers: A comparative literature review of Community Energy in the UK, Germany and the USA, the benefits it provides for society and the barriers it faces. Renewable and Sustainable Energy Reviews, 94, 187–196. https://doi.org/10.1016/j.rser.2018.06.013

European Commission. (n.d.). Energy communities. Energy Communities. Retrieved 31 January 2024, from https://energy.ec.europa.eu/topics/markets-and-consumers/energy-communities_en

European Commission. (2022, May 18). REPowerEU. REPowerEU: Joint European Action for More Affordable, Secure and Sustainable Energy. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

European Commission. (2023, February 14). CO_2 emission performance standards for cars and vans—European Commission. https://climate.ec.europa.eu/eu-action/transport/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en

Gallego-Castillo, C., Heleno, M., & Victoria, M. (2021). Self-consumption for energy communities in Spain: A regional analysis under the new legal framework. Energy Policy, 150, 112144. https://doi.org/10.1016/j.enpol.2021.112144

Lazaroiu, G. C., & Putrus, G. (2023). Renewable energy generation driving positive energy communities. Renewable Energy, 205, 627–630. https://doi.org/10.1016/j.renene.2023.02.001

Masip, X., Prades-Gil, C., Navarro-Peris, E., & Corberán, J. M. (2021). Evaluation of the potential energy savings of a centralized booster heat pump in front of conventional alternatives. Smart Energy, 4, 100056. https://doi.org/10.1016/j.segy.2021.100056

Palacios-Garcia, E. J., Moreno-Munoz, A., Santiago, I., Flores-Arias, J. M., Bellido-Outeirino, F. J., & Moreno-Garcia, I. M. (2018). A stochastic modelling and simulation approach to heating and cooling electricity consumption in the residential sector. Energy, 144, 1080–1091. https://doi.org/10.1016/j.energy.2017.12.082

Prades-Gil, C., Viana-Fons, J. D., Masip, X., Cazorla-Marín, A., & Gómez-Navarro, T. (2023). An agile heating and cooling energy demand model for residential buildings. Case study in a mediterranean city residential sector. Renewable and Sustainable Energy Reviews, 175, 113166. https://doi.org/10.1016/j.rser.2023.113166

van Bommel, N., & Höffken, J. I. (2021). Energy justice within, between and beyond European community energy initiatives: A review. Energy Research & Social Science, 79, 102157. https://doi.org/10.1016/j.erss.2021.102157

Walker, A., & Kwon, S. (2021). Analysis on impact of shared energy storage in residential community: Individual versus shared energy storage. Applied Energy, 282, 116172. https://doi.org/10.1016/j.apenergy.2020.116172

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

The Comprehensive And Unified Approach To Financing And Developing Sustainable Energy Education In Ukraine

Halyna Matviienko[a], Svitlana Kucherkova [b]

[a]V.I. Vernadsky Taurida National University, Department of Finance and Accounting Kyiv, Ukraine

[b]Dmytro Motornyi Tavria state agrotechnological university, Department of Finance and Accounting Zaporizhzhia, Ukraine

Abstract

This article delves into a comprehensive examination of strategies to finance sustainable energy education, considering the intricate economic landscape and the imperative need for skilled professionals in the field. Recognizing the pivotal role of education in fostering advancements in renewable and sustainable energy, the article advocates for a multi-faceted approach. The discussion begins by emphasizing the importance of cultivating skills that facilitate swift decision-making in uncertain environments, including critical thinking, adaptability, global citizenship, resilience, and creativity. Additionally, it highlights the necessity of enhancing the ICT competence of educators to form networks for scientific and research development in sustainable energy. The discussion extends to collaboration between universities and private entities through state-private partnerships, aiming to fund educational initiatives in sustainable energy. Emphasizing the role of local authorities, the article proposes regional allocation of universities to support and advise on sustainable energy transition, fostering close collaboration with businesses. Several strategies for financial incentives are explored, including direct funding through grants and subsidies, state grants for research, increased funding for universities offering sustainable energy programs, and tax incentives for educational institutions. In summary, the article advocates for a holistic and dynamic approach to financing sustainable energy education, emphasizing the pivotal role of education in nurturing a skilled workforce for the rapidly evolving field of renewable and sustainable energy.

Keywords: tertiary education; financing sustainable energy education; funding strategies.

How to cite: Matviienkoa, H. and Kucherkova, S. (2024) The comprehensive and unified approach to financing and developing sustainable energy education in Ukraine. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 447-455. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The energy situation in Ukraine is extremely complex, with a shortage of traditional energy sources. Hostile attacks on the energy infrastructure further exacerbating the situation, necessitating urgent actions for the development of a resilient energy infrastructure. Ukraine has a high potential for renewable energy sources (RES), but due to war, lack of investment, and the absence of comprehensive state support, the potential for the development of renewable energy is not fully realized. In Ukraine, immediate collaborative efforts are needed to change the course of development and rethink the future to achieve sustainable environmental development.

Education plays a crucial role in bringing profound, transformative changes to society and providing impetus for sustainable and innovative development in Ukraine, contributing to rapid post-war economic recovery. The modernization of the education system needs to commence promptly, as the preparation of highly skilled professionals with new competencies takes a considerable amount of time (Elif Bengu, 2020).

The future education system should provide opportunities for realizing its transformative potential to adapt to new conditions and contribute to the reconstruction of the economy, leveraging an economic breakthrough based on innovation. To achieve this, a new social contract for education is needed, along with the updating of the strategy for its transformation. Constructing a new social contract requires research on changes in the education system, opening new paths for innovative development and the recovery of Ukraine, as well as a re-evaluation of educational goals to attain long-term sustainability and individual success. Education should be oriented towards uniting people for the country's restoration and ensuring the development of science and innovation grounded in social, economic, and ecological justice and sustainability (Kandpal and Broman, 2014).

To achieve innovative economic development in the country, it is crucial to recognize key competencies required in the digital era, such as the ability to provide value beyond the capabilities of automated systems and intelligent machines; skills for working in a digital environment; and a continuous readiness to adapt to new methods of work and learning throughout one's life. Education is one of the most effective means of addressing societal issues (Elif Bengu, 2020).

The absence of a human resource with the necessary knowledge and skills is often identified as a key reason for the limited adoption of sustainable energy technologies. For the balanced and accelerated dissemination of various renewable energy technologies, along with enough competent and well-prepared professional workers. These professionals are needed for assessing resources, developing technology efficiency, system design, installation, operation, maintenance and technical servicing, performance monitoring, information

2024, Editorial Universitat Politècnica de València BY-NC-SA

processing, planning, and more. The training of qualified specialists is a critical success factor in implementing any development and dissemination strategy for renewable energy technologies (Dondi Marco, 2021).

It is necessary to periodically receive information from the industry regarding discrepancies between existing and desired levels of education and training, new technologies, and the need to develop new courses for professionals already working in the field of renewable energy sources. The development of necessary competencies is also crucial. Short-term professional training programs are exceptionally important and should be supported. Currently, adult education should be at the forefront of educational policies and strategies in most countries worldwide.

2. Result and discussion

According to the World Economic Forum data, there were ten types of skills required in the era of the Fourth Industrial Revolution, namely: complex problem-solving, coordination with others, people management, critical thinking, negotiation, quality control, service orientation, judgment and decision-making, active learning, and creativity.

Additionally, for the rapid implementation and use of Artificial Intelligence (AI) in the energy sector, it is necessary to develop cognitive awareness. Cognitive awareness is a primary skill that should be emphasized for the optimal utilization of advancements in AI generative systems. This ability reflects individuals' capacity to recognize their proficiency level in the necessary skills to perform specific tasks. Cognitive awareness becomes crucial if workers aim to restructure their work for increased productivity, choosing when and how to integrate AI system outputs (Dondi Marco, 2021).

In the face of an unstable external environment, it is crucial to focus on skills that facilitate quick decision-making in conditions of uncertainty, such as critical thinking, adaptability, global citizenship, resilience, and creativity. It is also advisable to develop the ICT competence of educators, enabling them to build networks for the advancement of science and research in the field of sustainable energy. Additionally, educators should possess qualifications and stay informed about global research trends to identify research directions and secure scientific support or grants from other countries. Therefore, it is important to initially enhance the qualifications of educators by organizing specialized professional development courses for them (Kandpal and Broman, 2014).

Furthermore, it is essential to develop competence in technological commercialization. Universities need to transition towards interdisciplinarity, open dialogue, and active collaboration with stakeholders.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

An important issue is the increase in investments in the energy sector, primarily in energy efficiency, renewable energy sources, and infrastructure. Meeting these investment needs is a challenging task in the current economic environment. Therefore, it is necessary to prepare professionals who can effectively evaluate energy projects, taking into account political, technological, and economic risks, considering changes in environmental taxes, and the emergence of new technologies and their potential. Hence, it is crucial to train specialists in emerging fields that meet the requirements of the new era and the needs of sustainable development (Momete D. and Momete M., 2021).

A key issue in the coming years is the allocation of finances for a sustainable energy transition. Such a transition will have a positive impact on long-term growth and employment, but in the short term, measures taken to decarbonize the energy system will inevitably result in costs. Therefore, it is important to consider this and carefully calculate the consequences of distributing various measures, as only a fair distribution of costs can guarantee political and social stability during the long-term transformation of the energy sector (Pellerin-Carlin et al., 2017).

Due to the challenging economic situation in Ukraine, initially, energy transformation should primarily be carried out with the support of grant funding, which can be obtained through various means such as investment grants, concessional loans, tax exemptions, and others. Key European funds that Ukraine can collaborate with include the Cohesion Fund, Connecting Europe Facility (CEF), Horizon 2020, LIFE, EIB lending, EFSI (Juncker Plan), Marguerite Fund, and the European Energy Efficiency Fund (EEEF). However, over time, market-based schemes should become the main resource.

It is advisable for education to maintain a constant connection with the energy sector of the economy regarding any discrepancies between existing and desired levels of education and training in renewable energy. This includes the need to implement essential courses for professionals already working in the energy sector and identifying the necessary skills and knowledge required by the current energy market. Achieving this requires significant efforts and changes in the field of education and training, as well as securing financial resources for the implementation of these changes (Momete D. and Momete M., 2021).

Government can stimulate increased funding for education in the field of sustainable energy through various strategies, utilizing both financial and non-financial approaches. The main ones include:

1. **Direct funding:** Governments can provide grants and subsidies to educational institutions, research centers, and organizations focused on sustainable energy education. This financial support helps cover operational expenses, research costs, and the development of new programs and specialties.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. **Government research grants:** Allocating funds specifically for research in the field of sustainable energy education. This may include grants for scientific institutions, analytical centers, and research organizations to conduct studies on sustainable energy practices and technologies.
3. **Increasing funding for universities offering sustainable energy programs:** This can encourage universities and colleges to invest in the development of relevant courses and research initiatives.
4. **Public-Private Partnership. Joint Initiatives:** Universities can collaborate with private companies and funds to finance educational initiatives related to sustainable energy. These partnerships can combine resources from both sectors to support research, develop educational curricula, and implement educational programs tailored to specific enterprises. The development and implementation of energy clusters are also possible (Pellerin-Carlin et al., 2017).
5. **Interaction and Support of Local Authorities in the Development of Energy Infrastructure:** Collaboration with local universities and the distribution of universities by regions they will support and advise during the sustainable energy transition, closely interacting with local businesses.
6. **Educational Grants and Scholarships:** Developing grant and financial aid programs to support students pursuing degrees or certifications in sustainable energy fields. This can make education more accessible and encourage individuals to choose a career in sustainable energy.
7. **Faculty Development Programs:** Increasing programs for the professional development of teachers, making these programs regular. This can enhance the overall quality of education in this field.
8. **Investments in Infrastructure:** Allocating funds for the modernization of educational infrastructure to support research and education in the field of sustainable energy. Collaborative inter-university and industry-related research centers where new equipment can be developed and tested.
8. **Tax Incentives for Educational Institutions:** Providing tax incentives for educational institutions offering sustainable energy programs. Oversight of these incentives through state certification of sustainable energy courses.
9. **Tax-Exempt Bonds for Sustainable Development Projects:** Issuing special green local bonds to support energy infrastructure projects in regions most affected by Russian aggression.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

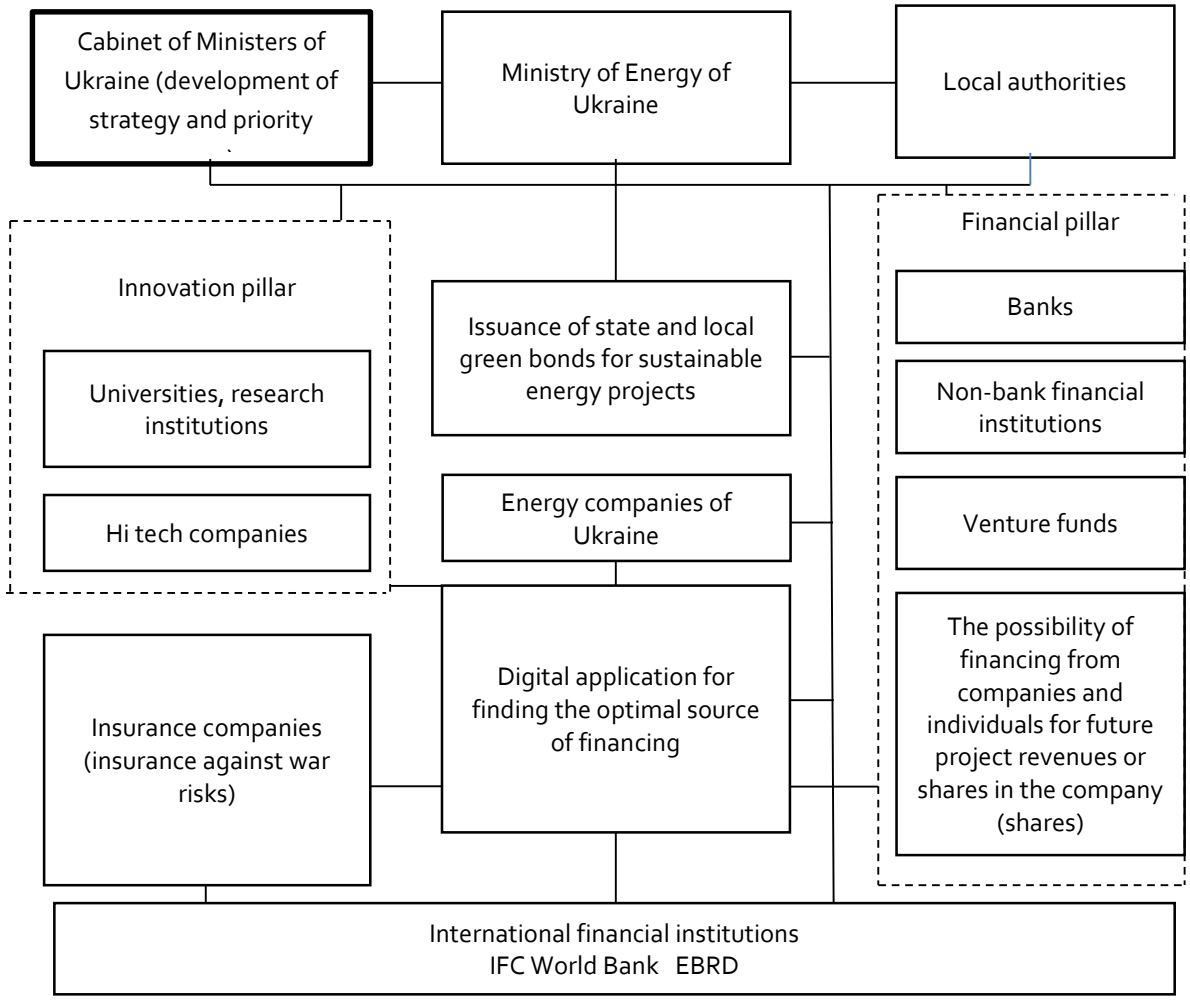
10. **Accelerated Depreciation for Sustainable Infrastructure:** Governments can provide accelerated depreciation schedules for investments in sustainable infrastructure.
11. **International Cooperation:** Ukraine is considered a prospective EU member, so it is crucial to explore opportunities for Ukraine to join the unified European energy space and participate in joint research and educational initiatives in the field of sustainable energy.
12. **Development of Regulatory Framework:** Developing a strategy and supportive policies to incentivize educational institutions to focus on sustainable energy.
13. **Development of Information Companies:** Public awareness programs, including investments in public awareness programs to highlight the importance of education in sustainable energy. This not only contributes to understanding but also builds public support for government initiatives in this area. The insufficient spread of renewable energy technologies is explained by a range of technological, economic, socio-cultural, and institutional barriers. Similarly, many socio-cultural and institutional barriers to the dissemination of renewable energy technologies can be overcome to a significant extent if potential end-users, policymakers, and other stakeholders become "energy-aware" by providing them with relevant information about various related issues, as well as measures to address them. Organizing special courses for public and local government officials on sustainable development and sustainable energy is also important (Pellerin-Carlin et al., 2017).
14. **Engagement of Financial Institutions:** Banks can play a crucial role in supporting sustainable energy education by providing financial resources and expertise. Loans for sustainable energy: Banks can offer specialized loans on favorable terms to educational institutions for the development of sustainable energy programs, research institutions, and infrastructure. These loans may have lower interest rates or longer repayment periods to encourage investments in sustainable education initiatives. Funding research and development through venture capital: This can contribute to innovation in the sector and promote the growth of businesses that contribute to sustainable education.
15. **Integration of Sustainable Energy Themes into Existing Curricula:** Ensuring that students from various disciplines are familiarized with the principles and practices of sustainable energy by integrating these themes into existing educational programs.
16. **Tax Revenues as a Source of Funding:** In Ukraine, one of the sources of funding for sustainable energy could be tax revenues, including excise tax, environmental tax, rent for the transportation of oil and oil products through main oil pipelines, transit transportation of ammonia through pipelines on the territory of Ukraine. It is possible

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

to allocate a portion of the budget expenditures, where the funding source for sustainable energy education could be revenues from these taxes and payments, at a level of 10%.

Since March 2024, enemy attacks on Ukrainian energy infrastructure have intensified across all regions of Ukraine, necessitating immediate innovative solutions for the rapid sourcing of financial resources for its recovery and ensuring its resilience. It is proposed to develop a digital application for financing projects aimed at the innovative restoration and resilience of the Ukrainian energy system. The scheme of interaction between participants in the implementation of software for finding sources of financing energy projects is shown in Figure 1.

Fig. 1 – The scheme of interaction between participants in the implementation of software for finding sources of financing energy projects



Source: own research

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The system will offer the most acceptable and cost-effective source of financing for specific project, involving international experts and organizations. With the development of a project evaluation methodology for a country in a state of war, to ensure transparency and efficiency in the allocation and distribution of funds, it would be prudent to provide justification for the financing source proposed by the program, as well as the possibility of engaging consultants to refine the project and assist with the documentation. Additionally, all banking and non-banking financial institutions can submit their requirements for project financing and current lending programs. This system (program) will ensure rapid financing of damaged energy infrastructure objects and provide for the innovative restoration and resilience of Ukraine's energy system. Furthermore, this application can implement targeted financing of projects by institutions and citizens.

3. Conclusion

By employing a combination of these strategies, governments can promote the development of a skilled workforce and foster research and innovation in the field of sustainable energy education. It is also crucial to implement mechanisms for monitoring and evaluating the quality of educational programs in sustainable energy. This can ensure that the education provided meets necessary standards and is continually improved.

This can be achieved through the recognition and accreditation of such programs, including on an international level. Therefore, the widespread utilization of new and renewable energy sources to make a significant contribution to global energy needs will require substantial technological efforts. The development and dissemination of relevant renewable energy technologies will demand a sufficient number of well-prepared and competent professionals. Hence, education and training in sustainable energy overall, and in new and renewable energy sources in particular, are extremely crucial (Elif Bengu, 2020).

The necessity and relevance of providing education in sustainable energy at all levels are acknowledged worldwide. Numerous countries around the globe have initiated educational programs in sustainable and renewable energy. Designing, developing, and disseminating appropriate renewable energy technologies are vital to meet the growing energy needs for economic growth and enhance the quality of life. Therefore, developing financing strategies for sustainable energy education is highly important for the rapid recovery of Ukraine's economy and its commitment to innovative and sustainable principles.

Acknowledgements

No funding has been received for the development of the research.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Dondi Marco (2021), Defining the skills citizens will need in the future world of work. *McKinsey.* Available at: https://www.mckinsey.com/industries/public-sector/our-insights/defining-the-skills-citizens-will-need-in-the-future-world-of-work#/ (accessed 15 November 2023)

Elif Bengu (2020). Rethinking higher education for the emerging needs of society. *Global solution journal. Issue 5*. Available at: https://www.global-solutions-initiative.org/wp-content/uploads/2020/04/GSJ5_Abrignani_Yilaz_Bengu_Sabuncuoglu.pdf

Momete, Daniela Cristina, and Manuel Mihail Momete. (2021). "Map and Track the Performance in Education for Sustainable Development across the European Union" *Sustainability* 13, no. 23: 13185. https://doi.org/10.3390/su132313185

Pellerin-Carlin, Thomas, Vinois, Jean-Arnold, Rubio, Eulalia, Fernandes, Sofia, Delors, Jacques, & Letta, Enrico (2017). Making the energy transition a European success Tackling the democratic, innovation, financing and social challenges of the energy union (INIS-FR--17-0891). France https://institutdelors.eu/wp-content/uploads/2018/01/ch3-makingtheenergytransitionaeuropeansuccess-study-pellerincarlinfernandesrubio-june2017.pdf

Tara C. Kandpal , Lars Broman (2014) Renewable energy education: A global status review. https://doi.org/10.1016/j.rser.2014.02.039

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Towards Sustainable Academia: Unveiling Trends and Challenges in University Energy Education in Zimbabwe

Bright Chisadza[a], and Keith Phiri[b]

[a]Lupane State University, Faculty of Agriculture, Department of Crop and Soil sciences, P. O Box 170, Victoria Falls Rd, Lupane, Zimbabwe

[b]Lupane State University, Faculty of Humanities and Social Sciences, Department of Development Studies, P. O Box 170, Victoria Falls Rd, Lupane, Zimbabwe

Abstract

This study explores the state of university energy education in Zimbabwe, examining trends, challenges, and opportunities for improvement. A mixed-methods approach was employed, including interviews, surveys, and document analysis. The research revealed a diverse range of energy education programs, with renewable energy as the dominant focus. While universities demonstrate a commitment to continuous improvement through planned modifications and long-term goals, key challenges include limited funding, faculty expertise, and student engagement. This paper highlights the need for strategic resource allocation, collaboration with industry partners, and fostering of engaging extracurricular activities to enhance the overall effectiveness of university energy education in Zimbabwe. This study contributes valuable insights for policymakers, educators, and institutions seeking to strengthen energy education and equip future generations to address complex energy challenges.

Keywords: University energy education; renewable energy; Zimbabwe, Sustainable energy future .

How to cite: Chisadza,B. and Phiri,K (2024) Towards Sustainable Academia: Unveiling Trends and Challenges in University Energy Education in Zimbabwe. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 456-464. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The increasing global demand for energy, coupled with pressing climate change concerns, necessitates a paradigm shift towards sustainable energy sources (Akpan & Olanrewaju, 2023). Universities, serving as centers of knowledge production and educators of future leaders, bear a significant responsibility in facilitating this transition. They play a role in equipping students with the essential skills and knowledge to navigate the dynamic and evolving energy landscape (Abulibdeh et al., 2024; Al Husseiny & Munna, 2024). This study focuses on Zimbabwean institutions as a case study, aiming to provide insights into the current state of university energy education in the context of a developing country.

While numerous studies have delved into energy education (Forinash et al., 2021; Motala et al., 2023; Zafar et al., 2020) at the university level, a noticeable gap exists in the research specifically tailored to the circumstances of developing countries such as Zimbabwe. This paper addresses this gap by presenting a thorough analysis of energy education trends and the challenges faced by universities within this specific region. Recognizing the unique dynamics of Zimbabwe not only contributes to localized solutions but also offers valuable insights applicable to other developing nations striving to forge sustainable energy futures.

By exploring the energy education landscape in Zimbabwean universities, this research aims to identify areas of strength, uncover challenges, and propose recommendations that can be adapted and tailored to meet the unique needs of developing countries. By doing so, this study endeavours to contribute meaningfully to the broader discourse on energy education, emphasizing the importance of context-specific considerations in shaping effective and sustainable academic initiatives.

2. Methodology

2.1 Study area

The study was conducted at five local Zimbabwean Universities: Lupane State University (LSU), the National University of Science and Technology (NUST), the Chinhoyi University of Technology (CUT), Midlands State University (MSU), and the University of Zimbabwe (UZ). These universities are located across five provinces, representing diverse economic and social realities (rural vs. urban environments). Their sizes also vary, with UZ having the largest enrolment and program offerings, while Lupane State University is the smallest. These differences highlight the range of energy needs and educational contexts within Zimbabwe.

2.2 Data collection

This study employed a comprehensive approach, utilizing both primary and secondary data to investigate trends and challenges in university energy education, with a focus on sustainability. A purposefully selected sample of lecturers actively engaged in energy

BY-NC-SA 2024, Editorial Universitat Politècnica de València

teaching at both the course and degree levels participated in the study. An online questionnaire, meticulously crafted and distributed via Google Forms, gathered valuable insights from these faculty members. This ensured a diverse and representative perspective on energy education within the universities. Extensive exploration of university websites and other relevant sources provided supplementary data on energy-related courses and learning programs. This secondary data enriched the understanding gained from the primary data.

The comprehensive utilization of both primary and secondary data sources strengthens the depth and breadth of this study, providing a nuanced understanding of the dynamics within university energy education.

2.3 Data analysis

This study employed a comprehensive approach, utilizing both primary and secondary data to investigate trends and challenges in university energy education, with a focus on sustainability. The primary data collection involved interviews and a purposefully selected sample of lecturers actively engaged in energy teaching at both the course and degree levels. To gather these primary data, an online questionnaire was meticulously crafted and administered via Google Forms. The questionnaire, designed to elicit valuable insights, was distributed to a diverse and representative sample of lecturers, ensuring a broad range of perspectives.

In parallel, secondary data were gathered through an extensive exploration of university websites and other relevant sources. This process aimed to supplement and enrich the primary data by obtaining additional information on energy-related courses and learning programs. Qualitative data from open-ended questions was thematically analysed to understand the experiences and perspectives of faculty members delivering energy education programs. The comprehensive utilization of both primary and secondary data sources strengthens the depth and breadth of this study, providing a nuanced understanding of the dynamics within university energy education.

3. Results and discussion

3.1 Assessment of the Current Energy Education Landscape

The assessment revealed a noteworthy distribution of participation among universities. While 50% of the respondents came from LSU, highlighting its active involvement, UZ and MSU exhibited lower engagement, both with only 9.1%, of the responses. This noteworthy distribution highlights the distinctive involvement of different institutions in the assessment.

Zimbabwean State Universities offer a diverse range of programs and courses strategically designed to address the challenges and opportunities of sustainable energy. These offerings

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

include specialized programs such as BEng in Renewable Energy, MSc in Renewable Energy, Instrumentation and Measurement Systems, BEng (Hons) in Fuels and Energy Engineering, BSc Honours in Natural Resources Management, and Solar Energy Courses (specific details available on university websites or program brochures).

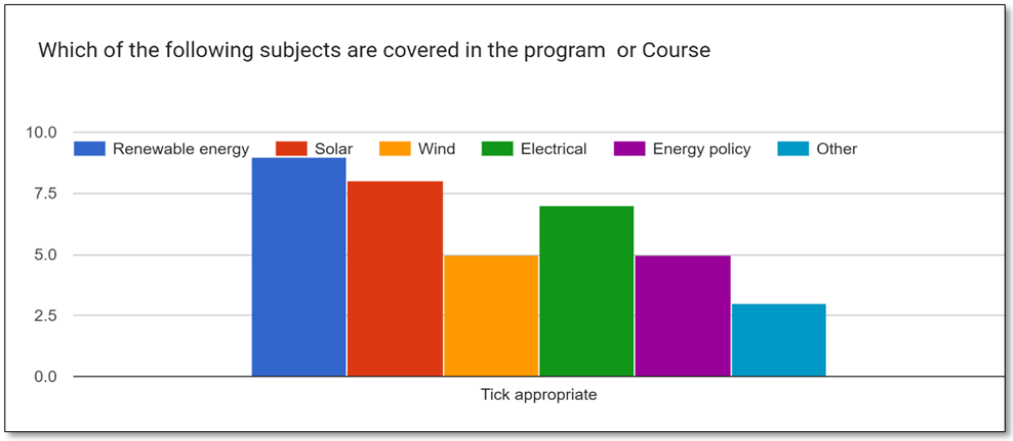
Approximately 58.5% of the respondents confirmed the existence of full-degree programs dedicated to energy education, spanning four to five years. These programs provide a thorough grounding in sustainable energy concepts (Fatmawati et al., 2024). Additionally, various shorter courses ranging from one to two semesters cater to diverse learning needs and timeframes. These options include solar cooling and air conditioning, which offer flexibility for individuals seeking professional development or specialized knowledge.

This assessment underscores the prevalence of comprehensive energy education programs within Zimbabwean State Universities. The diverse range of offerings caters to various educational needs and timeframes, from full-degree programs to shorter courses. While LSU exhibited active participation, further investigation is needed to understand the reasons behind UZ's and MSU's lower engagement.

3.2 Coverage of energy courses/programs

The assessment also analysed the subject areas covered within energy education programs. A significant trend emerged, with a majority of respondents highlighting a strong focus on renewable energy, as reflected in Figure 1. In contrast, energy policy was identified as the least covered subject, indicating a clear thematic preference among the respondents. This disparity sheds light on the areas of emphasis within the energy education landscape and warrants further investigation into the potential reasons behind the limited coverage of energy policy.

Figure 1: Subjects covered by the program



Source: Authors

BY-NC-SA 2024, Editorial Universitat Politècnica de València

While renewable energy course is consistently offered across all universities, variations exist in terms of the academic departments delivering these programs. Notable departments include agriculture, electrical/electronic engineering, industrial engineering, fuels and energy, and geography. This diversity reflects the integration of various disciplinary perspectives into the energy education curriculum, enriching the learning experience for students (Abulibdeh et al., 2024).

To gauge student satisfaction, a Likert scale was used in the questionnaire. The findings revealed a nuanced response, with 41.7% of respondents indicating a moderate level of satisfaction. Only 8.3% expressed the least satisfaction. These results suggest a generally positive sentiment towards the energy education programs, with a substantial portion of students reporting moderate contentment. However, the significant number of moderately satisfied students also indicates potential areas for improvement.

The results identified key strengths and areas for improvement within the current energy education landscape (Maynard et al., 2021). The prevalence of renewable energy courses is commendable, but the limited coverage of energy policy necessitates further exploration. Additionally, understanding the reasons behind moderate student satisfaction will be crucial for enhancing the quality and effectiveness of the programs. These insights provide a valuable foundation for developing informed recommendations aimed at strengthening the overall energy education landscape at Zimbabwean State Universities.

3.3 Factors influencing the adoption of renewable energy programmes and challenges

This assessment delved into the driving forces behind the adoption of renewable energy programs. A total of 100% of the respondents identified prevailing national energy trends as the primary motivator. This highlights the strategic alignment of academic offerings with the evolving energy landscape, ensuring that graduates possess relevant skills and knowledge for emerging job markets. Additionally, acknowledgement of factors such as student demands (8.3%), government incentives (16.7%), and faculty interest (8.3%) underscores a multifaceted approach to program adoption, considering diverse stakeholder needs.

Despite the evident commitment, program implementation faces various challenges, with 83% of respondents reporting difficulties. The most significant hurdle is limited funding, cited by 58% of participants. Other notable challenges include faculty expertise (25%) and curriculum development (1%). Furthermore, respondents emphasized a broader lack of resources (laboratory, equipment, software) hindering program effectiveness.

This analysis provides a nuanced understanding of the factors influencing program adoption and implementation. This study reveals the strong motivation for renewable energy education, which is aligned with national trends and stakeholder needs (Zafar et al., 2020). However, significant challenges, particularly financial constraints and resource limitations,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

require strategic interventions. Addressing these issues is crucial for the sustained success and growth of renewable energy education initiatives across Zimbabwean universities.

3.4 Student Engagement and Extracurricular Activities in Renewable Energy Education

The results revealed a predominant majority (41.7%) of programs or courses with enrolment between 1 and 20 students. Additionally, 8.3% of the programs have not yet commenced enrolment, indicating potential areas for program development and targeted marketing to attract students. This distribution highlights the need for strategies to broaden student participation and ensure the sustainability of existing programs.

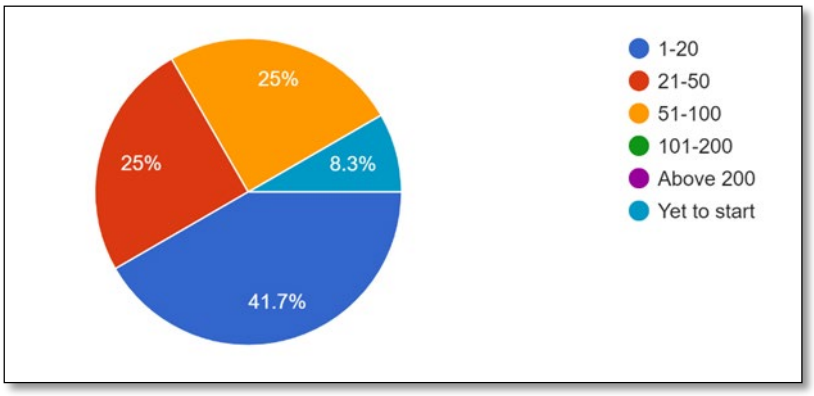
The staffing landscape shows that 75% of universities have dedicated teams of 1-5 faculty members for renewable energy education. The remaining 25% have slightly larger teams of 6-10 members. This compact but dedicated faculty underscores the importance of resource optimization and collaborative efforts to effectively deliver programs. Considering the diverse range of renewable energy topics, strategies to enhance faculty expertise and encourage interdepartmental collaboration could be beneficial.

The assessment identified a diverse range of student organizations and extracurricular activities focused on renewable energy, including workshops, competitions, and conferences. These initiatives enrich the educational experience by providing practical application and fostering a vibrant learning community (Motala et al., 2023). This multifaceted approach aligns with the dynamic nature of the field and encourages active student participation beyond traditional coursework. Expanding the reach and accessibility of these activities could further engage students and foster their passion for renewable energy.

These findings reveal insights into enrolment, staffing, and extracurricular activities within the energy education landscape. Program growth opportunities, strategic resource allocation to support faculty, and expanding engagement in student activities are key areas for further development. Building upon this foundation, Zimbabwean universities can continue to enhance their renewable energy education offerings and empower future generations to address the critical challenges and opportunities in this vital field.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 2: Enrolment in various programs or courses.



Source: Authors

3.5 Future Prospects and Long-Term Goals in Renewable Energy Education

The assessment revealed a promising future for renewable energy education at Zimbabwean universities characterized by a proactive approach to adaptation and advancement. A majority of respondents (58.3%) expressed plans to modify existing energy courses, demonstrating a commitment to continuous improvement. The envisioned changes encompass a forward-looking approach, including the introduction of remote labs, the incorporation of artificial intelligence, the implementation of short courses, and a comprehensive review of course synopses to integrate emerging issues linked to climate change.

Planning extends beyond immediate modifications, with universities aiming for a thorough review of existing programs and the introduction of new programs and short courses. This strategic foresight ensures alignment with the evolving energy landscape, guaranteeing that graduates possess the necessary skills and knowledge for future careers.

Key informants identified promising untapped opportunities for further enriching energy education. Among these opportunities, the most important ones raised include, partnering with industry partners and other universities can enhance the practical relevance of programs, establish valuable connections for students, and facilitate career paths. Additionally, focusing on new skills development ensures graduates stay at the forefront of industry demands and technological advancements.

By embracing these planned modifications, long-term goals, and untapped opportunities, Zimbabwean universities can position themselves as leaders in providing cutting-edge renewable energy education. This proactive and adaptive approach will equip future generations with the skills and knowledge necessary to address the challenges and opportunities of a sustainable energy future.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4. Conclusion and recommendations

The exploration of university energy education in Zimbabwe revealed a landscape with promising potential and noteworthy challenges. Universities offer diverse programs, predominantly focused on renewable energy, showcasing a commitment to alignment with national trends and stakeholder needs. However, limited funding, faculty expertise, and student engagement pose hurdles to program effectiveness.

Recommendations:

- Encourage interdepartmental collaboration and seek external partnerships to address faculty resource limitations.
- Expand outreach, diversify extracurricular activities, and integrate real-world applications to attract and retain students.
- Partners with industry players can enhance program relevance, provide internship opportunities, and facilitate graduate career paths.
- Regularly review programs, incorporate emerging trends, and leverage technology to ensure that graduates possess the necessary skills for a sustainable energy future.

Acknowledgements

We would like to express our sincere gratitude to the faculty members at Lupane State University, the National University of Science and Technology, the Chinhoyi University of Technology, Midlands State University, and the University of Zimbabwe who participated in this study. Their valuable insights were instrumental in shaping this research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Abulibdeh, A., Zaidan, E., & Abulibdeh, R. (2024). Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. Journal of Cleaner Production, 437, 140527. https://doi.org/10.1016/J.JCLEPRO.2023.140527

Akpan, J., & Olanrewaju, O. (2023). Sustainable Energy Development: History and Recent Advances. *Energies 2023, Vol. 16, Page 7049*, *16*(20), 7049. https://doi.org/10.3390/EN16207049

Al Husseiny, F., & Munna, A. S. (Eds.). (2024). *Revitalizing the Learning Ecosystem for Modern Students*. https://doi.org/10.4018/979-8-3693-4103-2

Fatmawati, S., Rahardjo, S. B., Harjana, H., & E., E. S. (2024). Problem-solving skills, collaborative skills and the theme of sustainable energy: Perceptions of students and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

lecturers in electricity lectures. *AIP Conference Proceedings*, *3058*(1), 020031. https://doi.org/10.1063/5.0200935

Forinash, K., Perkins, J. H., & Whitten, B. (2021). Background, approaches, and resources for teaching energy in environmental studies. *Journal of Environmental Studies and Sciences*, *11*(4), 708–734. https://doi.org/10.1007/S13412-021-00671-8/METRICS

Maynard, C., Garcia, J., Lucietto, A., Hutzel, W., & Newell, B. (2021). Experiential Learning in the Energy Based Classroom. *International Journal of Engineering Pedagogy (IJEP)*, *11*(6), 4–26. https://doi.org/10.3991/IJEP.V11I6.16539

Motala, S., Woldegiorgis, E. T., & Nyoni, P. (2023). *Changes and Continuity in the Roles and Functions of Higher Education in Sub-Saharan Africa*. Brill. https://brill.com/display/book/9789004677432/BP000012.xml

Zafar, M. W., Shahbaz, M., Sinha, A., Sengupta, T., & Qin, Q. (2020). How renewable energy consumption contribute to environmental quality? The role of education in OECD countries. *Journal of Cleaner Production*, *268*, 122149. https://doi.org/10.1016/J.JCLEPRO.2020.122149

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

How can we teach sustainability? Active learning based on an experimental game

Sabrina Fontanella[a], Luca Fraccascia[a-b], Fabio Nonino[a] and Alessandra Scarnicchia[a]

[a] Department of Computer, Control, and Management Engineering "Antonio Ruberti", Sapienza University of Rome, Italy

[b] Department of High-Tech Business and Entrepreneurship, University of Twente, The Netherlands

Abstract

This article investigates the impact of educational business games for undergraduate students understanding and implementation of sustainable management. With a focus on the intersection of sustainable development, education, and technology, the study addresses the need to equip future managers with skills for sustainability. By leveraging digital platforms and sustainable management, the research introduces a novel approach to engage the 'gamer generation' in sustainability education. Through the design and implementation of a digital business game, the study aims to teach undergraduate students (form the age of 17 to the age of 23) the fundamentals of within a sustainability framework. Drawing from a growing body of literature on sustainable business models, the paper contributes to the discourse on sustainable business practices and innovative educational methodologies. Preliminary findings from the game testing phase offer insights into its effectiveness as a tool for fostering sustainability literacy among students. This research aligns with global efforts towards a sustainable future, highlighting the potential of educational games in promoting sustainable business practices among the next generation of leaders.

Keywords: Sustainable education; Business game; New educative technology; High schools.

How to cite: Fontanella, S.; Fraccascia, L.; Nonino F. and Scarnicchia, A. (2024) How can we teach sustainability? Active learning based on an experimental game. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 465-472. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The imperative of economic, social, and environmental sustainability is underscored in the contemporary global landscape (Evans et al., 2017). Businesses play a crucial role in advancing sustainable development agendas (Evans et al., 2017; Wells, 2013). Sustainable business models, as defined by Dyllick and Hockerts (2010), incorporate principles of economic, environmental, and social sustainability, facilitating reductions in consumption while generating financial and social benefits through innovation. The influence of digitization reshapes business paradigms, fostering novel sustainable activities (Parida et al., 2019; Valcozzena et al., 2023). Sustainable entrepreneurship integrates environmental and social considerations within business strategies (Dyllick and Hockerts, 2010; Lin et al., 2020).

Education serves as a vital conduit for instilling sustainable development principles (Battistella et al., 2021). Traditional methods often struggle to engage younger generations in sustainability actions and mindset. Educational business games blend entertainment with education, offering a promising way to engage and raise sustainability awareness among the 'gamer generation' (Baldissin et al., 2013). These games simulate real-world scenarios, fostering critical thinking, collaboration, and entrepreneurial skills essential for addressing sustainability challenges (Greco et al., 2013; Fraccascia et al., 2021), providing participants with a deep understanding of sustainable business models (Baldissin et al., 2013).

In light of these considerations, this paper seeks to address the gap in sustainability education by understanding how a business simulation game tailored for undergraduate students, considering them as scholars of last years of high schools and university (form the age of 17 to the age of 23), can impact on a variety of soft and hard skills related to sustainability.

2. Relevance of research

2.1 Business games for sustainability

Sustainability education has emerged as a crucial driver of societal change, prompting the integration of sustainable development principles across educational levels (Shin-jia et al., 2022). The 2030 Agenda underscores the necessity of sustainability education, with UNESCO and the UN advocating for the use of educational games, an engaging and self-regulated way of learning, to address environmental and social challenges (Santos-Villalba et al., 2020). Educational games offer a promising avenue for sustainability education, overcoming the limitations of traditional teaching methods by enhancing motivation and intrinsic engagement (Vergara et al., 2020). Business games, specifically, have been identified as effective tools for sustainable energy education, providing immediate feedback and fostering pro-environmental attitudes among students (De la Torre et al., 2021). By incorporating game elements, educational tools enhance emotional, cognitive, and behavioural potential,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

aligning with social interaction and promoting sustainability values (De la Torre et al., 2021). Simulation-based business games prove instrumental in conveying sustainable skills and concepts, modelling dynamism and potential world changes over the medium to long term (De la Torre et al., 2021). However, the efficacy of business games hinges on effective design and integration of sustainability principles into students' value systems (Flood et al., 2018).

Non-traditional teaching methods, emphasizing transformative learning environments, integrate sustainability into scientific methods and align with intrinsic motivation theories (Wiek et al., 2014; Möller et al., 2021). Design elements in sustainability education games, such as those addressing water conservation or energy efficiency, consider diverse motivational factors and necessitate various gamification elements (Böckle et al., 2020). Furthermore, the educational role of business games extends beyond knowledge acquisition, promoting a systemic perspective and enabling individuals or teams to navigate complex business dynamics (Goold and Campbell, 2002). In modern business landscape, rapid knowledge absorption and acquisition of new competencies are essential, driving the need for innovative managerial training methodologies like business games (Baldissin et al., 2013). Thus, integrating sustainability principles into business games offers a holistic approach to preparing future managers for the challenges of sustainable development.

2.2 Contribution

Our research aims to assess the impact of a new business simulation game on students' understanding and attitudes toward sustainable business practices, improving sustainability education and business teaching methods. This study is significant for its innovative game design, addressing gaps in existing literature on sustainable business activities. Unlike traditional simulations, our game is customized to foster the development of enterprises dedicated to economic, social, and environmental sustainability form their starting point.

Additionally, our focus is on undergraduate students, a demographic often neglected in sustainability education efforts. By involving students at this critical stage, our simulator seeks to influence their attitudes and decision-making toward sustainable entrepreneurship early on. As a result, this paper contributes to academia by evaluating a practical tool aimed at instilling sustainability principles in future leaders and entrepreneurs.

3. Method

3.1 Game structure

The Sustainable Management Business Game (SMBG) provides undergraduate students with an immersive exploration of sustainable decision-making processes. Divided into two parts, it allows participants to develop sustainable business ideas and navigate real-world market dynamics. The SMBG immerses participants in managing a clothing company catering to an

BY-NC-SA 2024, Editorial Universitat Politècnica de València

ethically conscious consumer base. This requires re-evaluating the business model to integrate economic viability, environmental stewardship, and social responsibility. Participants must balance these dimensions for sustainable success. The SMBG unfolds in two distinct phases, each offering students the unique opportunities for experiential learning and skill development:

Part 1 – From idea to market: The initial section introduces key management, sustainability, and sustainable business concepts, including a quiz with five questions to assess participants' understanding. Participants then delve into the Sustainable Business Model Canvas (BMCS) by Cardeal et al. (2020), using a practical example of a company producing sustainable smartphones. Decisions are evaluated against the nine blocks of the Canvas, considering economic, environmental, and social sustainability aspects. Each decision impacts sustainability dimensions and influences a final feedback score, the starting point for part 2.

Part 2 – Run the business: The next phase of the business simulation lead participants into a dynamic scenario shaped by the ongoing narrative of sustainable business. Progressing one year from the introduction of the new product line, now participants are asked to deal with real-world market scenarios, where strategic decisions are required to succeed. The second phase unfolds across eight rounds, akin to business semesters, each presenting evolving challenges and opportunities. In each round, participants confront strategic and managerial dilemmas with choices that impact sustainability perspectives and economic indicators.

- Round 1: Participants hire a sustainability monitor for certification and select promotion channels.
- Round 2: Decisions focus on transportation services and shipment solutions.
- Round 3: Choices include packaging solutions, employee satisfaction initiatives, and investments in climate resilience.
- Round 4: Emphasis is on waste management and addressing air pollution impacts.
- Round 5: Decisions involve social media marketing, supporting sustainable mobility, and managing energy costs.
- Round 6: Participants select production materials and manage supply chains.
- Round 7: Choices include product line characteristics, promotional strategies, and supporting sustainable mobility initiatives.
- Round 8: Focus is on production management and waste reduction for the new business line.

Moreover, during the 8 rounds, unexpected events introduced strategically add unpredictability mirroring real-world challenges, requiring adaptability from participants.

The decision-making process integrates numerical and descriptive elements, fostering reflective and critical thinking. Feedback includes simplified indicators for economic,

2024, Editorial Universitat Politècnica de València BY-NC-SA

environmental, and social perspectives, alongside visual representations of performance metrics. This design ensures coherence and offers players latitude to make coherent choices, enhancing replay-ability. This because the game's flexibility allows for multiple strategies, emphasizing the nuanced interplay between initial conditions and subsequent performance across economic, environmental, and social perspectives.

In the SMBG some performance metrics are considered aimed at evaluating the efficacy and impact of students' decision-making processes:

- Economic Value (VE): represent financial viability and profitability of the company, this metric is a tangible insight into the economic performance, fostering strategic thinking and resource allocation.
- Environmental Value (VA): Reflecting the commitment to sustainability through initiatives such as emissions reduction, use of recycled materials, and responsible waste management.
- Social Value (VS): Evaluating initiatives related to employee training, customer satisfaction, and partnerships promoting fair working conditions.

3.2 Intended learning outcomes

The intended learning outcomes of the SMBG are encapsulated in three fundamental principles that underpin the educational journey of participants:

1) Becoming aware of the **managerial strategies to enhance the sustainability of the industrial activity**: participants become aware that several strategies can be adopted by company managers to reduce the environmental and social impact of their production processes. These strategies are mainly associated with the circular economy paradigm (with reference to the environmental impact) and the business ethics (with reference to the social impact) perspective.

2) Experiencing **Sustainability Decision-Making**: Through experiential learning and reflective practice, participants acquire the requisite skills for informed decision-making, navigating the multifaceted implications of their choices and fostering a capacity for sustainable entrepreneurship.

3) Becoming aware of the **Trade-off between the three pillars of sustainability**: Participants gain a deep understanding of the interconnected nature of economic, environmental, and social dimensions, recognizing that imbalance in one area invariably impacts others, thereby emphasizing the importance of maintaining equilibrium across all three dimensions. Furthermore, the SMBG elucidates the dynamic interplay among economic, environmental, and social aspects, emphasizing that decisions undertaken by participants exert a simultaneous

BY-NC-SA 2024, Editorial Universitat Politècnica de València

influence across all three dimensions, underscoring the holistic nature of sustainability considerations.

4. Data gathering and feedback

In order to evaluate the effects of the game on the designated audience, two distinct test methodologies were employed: one focusing on individual engagement and the other on collective gameplay experience. Within this preliminary phase, a cohort of approximately ten students participated, with 4 involved in the former test and 6 in the latter. Subsequent to their engagement with the game, participants provided feedback through a structured questionnaire administered by the instructor, aimed at assessing both the usability of the game and its impact on the anticipated learning outcomes. Several pertinent findings emerged from this analysis, including:

- The **collective gameplay mode demonstrated superior efficacy**, fostering discussion and idea exchange among participants.
- The game effectively facilitated the **acquisition of fundamental knowledge pertaining to sustainable enterprise** among students. Noteworthy concepts frequently highlighted by participants included the business model, the imperative of holistic consideration of the three categories, and the pursuit of equilibrium across dimensions.
- Participants reported finding the experience engaging in terms of **honing various interdisciplinary skills**, with particular emphasis placed on teamwork, decision making adaptability and strategic thinking.

5. Conclusion

The ongoing process of gathering feedback for the optimization of the game remains underway. Nevertheless, a sizable event is slated to take place in July, encompassing students from all departments of Sapienza University, with an estimated participation surpassing 150 individuals. This event is scheduled within the context of an open sustainability course.

Moreover, it can be posited that the game serves as a noteworthy preliminary stride toward instating active student instruction concerning the principles of sustainable enterprise, fundamental competencies pertinent to sustainability, and the capacity to cultivate a business intentionally aligned with sustainability objectives.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

This study was carried out within the Rome Technopole project – FP1, "Learning for Empowering Green Society", and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA – PNRR), CUP B83C22002820006.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Baldissin, N., Bettiol, S., Magrin, S., & Nonino, F. (2013). Business game-based learning in management education. Lulu. com.

Battistella, C., Murgia, G., & Nonino, F. (2021). Free-driven web-based business models. Electronic Commerce Research, 21, 445-486.

Böckle, M., Novak, J., & Bick, M. (2020). Exploring gamified persuasive system design for energy saving. Journal of Enterprise Information Management, 33(6), 1337-1356.

Cardeal, G., Höse, K., Ribeiro, I., & Götze, U. (2020). Sustainable business models–canvas for sustainability, evaluation method, and their application to additive manufacturing in aircraft maintenance. Sustainability, 12(21), 9130.

De la Torre, R., Onggo, B. S., Corlu, C. G., Nogal, M., & Juan, A. A. (2021). The role of simulation and serious games in teaching concepts on circular economy and sustainable energy. Energies, 14(4), 1138.

Dyllick, T.; Hockerts, K. (2010). Beyond the business case for corporate sustainability. Business Strategy and Environment, 11, 130–141.

Evans, S.; Vladimirova, D.; Holgado, M.; Van Fossen, K.; Yang, M.; Silva, E.A.; Barlow, C.Y. (2017). Business Model Innovation for Sustainability: Towards a Unified Perspective for Creation of Sustainable Business Models. Business Strategy and Environment, 26, 597–608.

Flood, S., Cradock-Henry, N. A., Blackett, P., & Edwards, P. (2018). Adaptive and interactive climate futures: systematic review of 'serious games' for engagement and decision-making. Environmental Research Letters, 13(6), 063005.

Fraccascia, L., Sabato, A., & Yazan, D. M. (2021). An industrial symbiosis simulation game: Evidence from the circular sustainable business development class. Journal of industrial ecology, 25(6), 1688-1706.

Goold, M., & Campbell, A. (2002). Designing effective organizations: How to create structured networks. John Wiley & Sons.

Greco, M., Baldissin, N., & Nonino, F. (2013). An Exploratory Taxonomy of Business Games. SAGE

Lin, P., Zhang, X., Yan, S., & Jiang, Q. (2020). Dynamic capabilities and business model innovation of platform enterprise: a case study of didi taxi. Scientific Programming, 1-12.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Möller, F., Stachon, M., Azkan, C., Schoormann, T., & Otto, B. (2021). Designing business model taxonomies–synthesis and guidance from information systems research. Electronic Markets, 1-26.

Parida, V.; Sjödin, D.; Reim, W. (2019). Reviewing Literature on Digitalization, Business Model Innovation, and Sustainable Industry: Past Achievements and Future Promises. Sustainability, 11, 391, 1-18.

Valcozzena, S., Attanasio, G., Battistella, C., & Cantele, S. (2023). Exploring The Sustainable Business Model Of Digital Platforms: A Systematic Literature Review. Building Partnerships for more sustainable, resilient and regenerative business models, 1-8.

Vergara, D., Mezquita, J. M. M., Valecillo, A. I. G., & Fernández-Arias, P. (2020). Sistemas de respuesta de estudiantes: evolución hacia a la gamificación. Revista Eduweb, 14(2), 236-250.

Santos-Villalba, M. J., Leiva Olivencia, J. J., Navas-Parejo, M. R., & Benítez-Márquez, M. D. (2020). Higher education students' assessments towards gamification and sustainability: A case study. Sustainability, 12(20), 8513.

Shin-jia Ho, Yu-Shan Hsu, Chien-Hung Lai, Fong-Han Chen. Ming-Hour Yang, Applying Game-Based Experiential Learning to Comprehensive Sustainable Development-Based Education, Sustainability 2022.

Wells, P. (2013). Sustainable business models and the automotive industry: A commentary. IIMB. Management Review, 25, 228–239.

Wiek, A., Xiong, A., Brundiers, K., & Van der Leeuw, S. (2014). Integrating problem-and project-based learning into sustainability programs: A case study on the School of Sustainability at Arizona State University. International Journal of Sustainability in Higher Education, 15(4), 431-449.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Beyond Digital Survival…
Student Resilience and Acceptance of On-line learning in France

Nada Mallah Boustani[a], Loubna Mourtajji[b] and Nathalie Arts-Chiss[c]

[a]Faculty of Business & Management, Saint Joseph University, Social Science Campus, Beirut, Lebanon, and LEFMI (Laboratory of Economics, Finance, Management, and Innovation), Amiens, France

[b]University Institute of Technology of Oise, Creil Campus, University of Picardy Jules Verne, LEFMI (Laboratory of Economics, Finance, Management, and Innovation), Amiens, France

[c] University Institute of Technology of Oise, Beauvais Campus , University of Picardy Jules Verne, LEFMI (Laboratory of Economics, Finance, Management, and Innovation), Amiens, France

Abstract

The COVID-19 pandemic has precipitated a global shift to online education, prompting this study to investigate the adaptability of undergraduate students at a French university. Employing resilience theory, the research explores students' perceptions of online learning and the strategies employed for educational continuity. The study also integrates the Technology Acceptance Model (TAM) in a constrained context, examining the interplay between technology perception and individual resilience. A questionnaire survey conducted post-COVID, garnered responses from 402 students at the University Institute of Technology of Oise. The factor analysis identified three components related to teacher aspects, student emotional responses, and practical difficulties. Results indicate varied learning values across educational levels, with graduate students exhibiting higher values. Educational and technical support emerged as crucial for enhancing online learning experiences. The study aligns with the CCPT framework and Connectivism theory, emphasizing the integration of technology, pedagogy, and content knowledge. In conclusion, the study sheds light on factors influencing online learning experiences in the French context during the pandemic. Future research should delve deeper into identified factors, encompass diverse cultural contexts, and employ mixed methodologies for a comprehensive understanding.

Keywords: Educational innovation; Student perceptions; Digital technologies; Distance learning; Higher education.

How to cite: Boustani, N.M; Mourtajji, L and Arts-Chiss, N. (2024) Beyond Digital Survival…Student Resilience and Acceptance of On-line learning in France. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 473-482. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction and context of the study

The advent of the COVID-19 pandemic has brought about a radical and rapid transformation of the global educational landscape. This health crisis has forced educational institutions, from elementary school to universities, to switch to online teaching formats. This study focuses on the adaptability of undergraduate students at a French university institute, the first to close its doors during the pandemic. It aims to understand students' perceptions of online learning and the strategies they adopted to ensure continuity in their learning. While the COVID-19 pandemic has prompted much research into online education around the world, studies in France remain relatively limited. This study suggests an in-depth exploration of how students have adapted to using digital technologies in a challenging context, based on resilience theory and focusing on their ability to overcome challenges. Students affected by these initial confinements had to adapt suddenly to a new reality of isolation and distance learning, totally unforeseen, without adequate preparation or support. This may have led to feelings of loneliness and exclusion, as well as challenges in accessing educational resources and communicating effectively with teachers and classmates. In addition, the disparity of measures taken from one region to another may have seemed arbitrary and unfair, exacerbating feelings of frustration and incomprehension among these students.

The premise of this research is that, in a disrupted educational context such as the COVID-19 pandemic, resilience can influence the way students perceive and use technology for learning. Indeed, a resilient student might be more inclined to perceive technology positively in line with the Technology Acceptance Model (Davis, 1986) as an effective way to continue learning and improve communication with peers despite adverse circumstances. Conversely, a non-resilient student will tend to perceive the situation negatively and reject the adoption of any new technology (Zoom, Moodle). This interaction between technology perception and individual resilience creates fertile ground for technological adoption and adaptation in difficult situations. Conversely, digital networking, social support and participation in virtual groups (whatsapp, discord, snap chat) strengthen students' resilience, enabling them to better manage academic challenges and adapt more easily to the use of new educational technologies. These postulates are questioned based on generic elements such as gender, age, level of education (Bachelor Year 1, 2 or 3) and contextual elements such as the use and availability of digital tools, family support and stress.

2. Theoretical background

Our conceptual model is based on the Technology Acceptance Model (Davis, 1986) which conceptualizes the acceptance of technology by users (Venkatesh and Davis, 2000). In terms of education, studies have notably tested the adoption and acceptance (or not) of innovative technologies both from the point of view of teachers (Scherer et al., 2019) and students

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

(Mohammadi, 2015; Ibrahim et al., 2017; Rafique et al., 2020). However, the use and acceptance of the tools offered is done on a voluntary basis. On the contrary, the TAM model is used here in a constrained context created by the appearance of the pandemic and the obligation to resort to distance learning overnight without preparation or training. Specific situations have been tested in Jordan (Almaiah et al., 2020), Vietnam (Ho et al., 2020), Indonesia (Siron et al., 2020; Sukendro et al., 2020; Mailizar et al., 2021) or even in Germany (Vladova et al., 2021), but not in France where we propose to test an extended TAM model.

Resilience theory focuses on the ability of an individual, community or system to recover from adversities, defined as any difficult, stressful or traumatic experience or situation (Barrett et al. 2021). In the context of our study, the pandemic is an example of adversity, not just for students, but for the entire global population. It brought with it unprecedented health, economic and social challenges. The crisis imposed severe restrictions, such as confinement and social distancing measures, profoundly affecting students' daily lives, psychological well-being and social interactions. Economic disruption and the loss of student jobs have increased financial insecurity and left some students in precarious conditions. In addition, the constant threat to health and bereavement due to the loss of loved ones exacerbated their stress and anxiety. Resilience in this context involves adapting to all these circumstances, maintaining or recovering mental well-being, and being able to navigate an uncertain and constantly changing environment. Fisher et al. (2019) emphasized the need to consider the temporality of resilience. Indeed, they distinguish between an event that lasts over time and an event of short duration, a one-off event and a repetitive event. This temporality influences the ability to adapt. It covers the ability to adjust positively in the face of adversity. Students who adapted positively to the pandemic and coped with the changes, were able to recover more quickly and adopt all the tools offered by the institution, or even optimize them. Resilient students will not hesitate to develop support networks, which in turn will further strengthen their resilience.

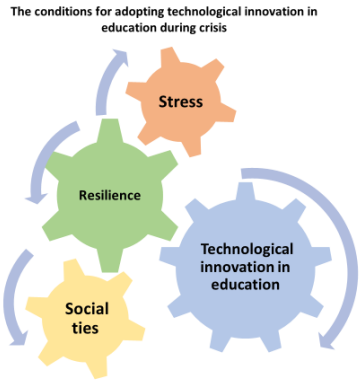
In the dynamic field of education, where traditional boundaries are being redefined by technological advancements, the role of innovation has taken center stage, revolutionizing both the learning experience and the art of teaching. In the era of online learning, the challenge and unique opportunity to transmit knowledge, but also to inspire a new generation to embrace change, adaptability, and a thirst for innovation. Universities, as incubators of tomorrow's professionals, have the heavy responsibility of producing graduates who not only master fundamental theories, but are also prepared to navigate the complexities of a rapidly changing global marketplace. Technological Pedagogical Content Knowledge (TPCK) is a framework that emphasizes the integration of technology, pedagogy, and content knowledge. It focuses on how teachers can effectively use technology to improve teaching and learning experiences. It recognizes the importance of aligning technology with

BY-NC-SA 2024, Editorial Universitat Politècnica de València

specific subject areas and teaching approaches in order to improve educational outcomes (Mishra and Koehler, 2006). Connectivism is a learning theory based on the importance of networked learning and the role of technology in facilitating learning. It recognizes that knowledge is distributed across networks and emphasizes the skills needed to navigate and make connections in digital spaces. Connectivism emphasizes the development of digital literacy, network analysis and learning across different platforms and resources (Siemens, 2004).

Our model focuses on the adoption by students of distance learning solutions made available by the establishment (Moodle, course sessions via Zoom for example) during the COVID-19 crisis, depending on their perceived usefulness and ease of use. We also integrate into our study the attitude of students towards solutions emanating from their initiative to exchange and recreate a semblance of a class or work group (Google drive, Snapchat, WhatsApp). Indeed, it appears that the social dimension (Ho et al., 2020; Vladova et al., 2021) can affect students' attitudes. The state of social isolation in which students found themselves without preparation is thus considered within the model.

Fig. 1 : Conceptual Model



Source : Own creation (2024)

3. Materials and Methods

3.1. Instrument Description

This study employed a questionnaire survey comprising three main sections. The first section deals with respondents' perceptions of distance learning courses. Material conditions of access are considered, as well as students' confidence in distance learning courses. More precisely, nine questions (using a 5-point central Likert scale) deal with students' experience in online education during pandemic. The question of stress is also addressed. Second section looks at the conditions under which distance learning was introduced at the University (Beauvais and Creil Campus), and how students used and appropriated the tools. The

 BY-NC-SA

organizational adaptation and resilience shown by the respondents are also questioned. The third part consists of a complete data sheet. In addition to gaining a better understanding of the respondents through classic socio-demographic criteria and criteria linked to studies and living conditions during the pandemic, the researchers were also interested in knowing whether the respondents had been directly affected by Covid.

3.2. Data Collection

This descriptive cross-sectional study was conducted on a non-probabilistic sample comprising 402 participants from either the Creil Campus (the 1st establishment to close its doors following the COVID) or the Beauvais Campus of the University of Picardy, 345 questionnaires were validated. Data collection spanned from February to March 2022 (after the lockdown), utilizing a computer/web-based methodology on www.limesurvey.com. The questionnaire was anonymous, and the administration of the questionnaire was carried out in the presence of a teacher. The standardization of administration is guaranteed by the protocol developed, with students invited to complete the questionnaire electronically during a work session in a computer room. Rigorous adherence to ethical principles was maintained throughout the questionnaire design and data collection processes.

3.3. Statistical Analysis

Statistical analysis in this study was carried out using SPSS Version 28 by IBM, Inc. (Armonk, NY, USA). Fundamental descriptive statistics were applied, and statistical tests were employed to assess variations among groups of variables. Parametric tests were favored due to their heightened strength and efficacy compared to non-parametric alternatives. In this scenario, a factor analysis (FA) was performed and throughout all tests, a significance level of 5% was upheld ($p < 0.05$). After the confirmation that data were suitable to apply FA (using the correlation matrix, the value of the Kaiser-Meyer-Olkin (KMO) measure of the adequacy and the Bartlett's test), this was performed with principal components analysis methods and Varimax rotation.

4. Data analysis and Results

4.1. Sample Characterization

A total of 345 valid responses were obtained, the sample is slightly skewed towards females (53.3%) compared to males (46.7%). A significant majority (98.3%) of respondents fall within the age range of 18-25 years old. The highest proportion of respondents are in the "Bachelor Year 3" category (49.3%), followed by "Bachelor Year 1" (32.2%) and "Bachelor Year 2" (18.6%). This suggests a diverse representation across different stages of higher education. Most respondents (81.4%) reside in Oise region, indicating a localized participant group. A considerable portion (78.6%) live with their parents, highlighting a significant dependence on family support. Nearly

BY-NC-SA 2024, Editorial Universitat Politècnica de València

half of the respondents (47.8%) were directly affected by COVID-19, while a higher percentage (82.9%) had relatives affected. This indicates a widespread impact within their social circles. Over 60% experienced anxiety during periods of distance learning, indicating potential challenges in adjusting to remote education. Around a third (31.9%) considered stopping their studies during this period, reflecting the difficulties they faced. The majority (92.8%) had the necessary IT tools for distance learning, but a notable portion (7.2%) did not, potentially affecting their educational experience. A significant number (62.6%) faced connectivity issues, which could have impacted their ability to engage effectively in remote learning.

4.2. Factor analysis results

The correlation matrix, a KMO value of 0.746 and Bartlett's Test of Sphericity with low p-value ($p<0.001$) verify the assumptions that the data were suitable to apply FA. The anti-image matrix revealed that all values of the correlations were over 0.5, and therefore neither of the variables should be excluded from the analysis (the lowest of the values was 0.632 for variable Q1, and the highest was 0.851 for variable Q8). Il this case, the first three components (with an initial eigenvalue of 2.837, 1.533 and 1.017, respectively) explain a cumulative percentage of 59.862% of the total variance in the data. This suggests that these three components capture most of the variability in the original variables and may be sufficient for research analysis (Table 1).

Table 1. Rotated Component Matrix

Rotated Component Matrix	***Component***		
	1	2	3
Do you think that teachers have used specific supports for distance learning courses?	0.855		
Do you think that teachers have demonstrated innovation in their distance learning?	0.841		
Has group work been made more difficult?		-0.67	
Have the distance learning courses strengthened the social cohesion of the class?		0.664	
Do you think the online exam scores truly reflected your level of education?		0.631	
How much confidence do you have in listening to distance learning courses?	0.455	0.507	
Did you feel more stress during the distance learning period?			0.852
Were you afraid of not getting your semester/year following distance learning courses?			0.83
How much confidence do you place in the teaching of distance learning courses?	0.397	0.415	-0.478
Rotation Method : Varimax with Kaiser Normalization (Rotation converged in 4 iterations)			

Source : Own Creation (2024)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The rotated component matrix simplifies the interpretation of the components. **Component 1 "Innovation and Support"** emphasizes teacher-related factors like innovation and specific support for distance learning. **Component 2 "Emotional Aspects"** focuses on emotional aspects such as stress, confidence in listening, fear of academic success, and perceptions of exam reflection. It represents emotional responses, including stress and concerns about academic success. **Component 3 "Resilience and Listening Confidence"** relates more to factors like group work difficulty, confidence in pedagogy, and confidence in distance course listening. This component appears to represent a mix of factors related to the experience of distance learning and its impact on academic progression and confidence in teaching.

5. Discussion

The study aimed to assess student attitude with online learning, particularly during the COVID-19 pandemic. We can argue that facilitating conditions and learning value have been identified as having a positive impact on online learning, leading to an acceptance of online engagement even beyond the pandemic. Additionally, variations in learning values were observed across different education levels, with graduate students showing higher values. The study highlighted the importance of educational and technical support from institutions to enhance students' online learning experience. The contribution of the article aligns with the CCPT framework as it addresses the integration of technology (online learning platforms) with pedagogy (effective teaching strategies) and content knowledge (implementation program implementation) in the context of online learning during a crisis. Connectivism theory recognizes the changing dynamics of learning in the networked digital age. The research is interested in how management education adapts in times of health crisis compared to traditional technical training, especially since the COVID-19 pandemic has accelerated access to new tools and news realities of online learning. The study highlights the importance of digital literacy, networked learning, and the ability to navigate and connect to resources in online environments. Future research opportunities deal with embracing technology-assisted learning, promoting educational innovations, collaboration and networking, and student support and engagement. This article also integrated resilience as a catalyst to influence the adoption of new technology in the event of a Crisis. Indeed, adaptability, perseverance and social bonding enabled students to have a positive attitude towards technology. The most resilient students used a variety of innovative teaching tools and were able to adapt to the resulting changes. Resilience is not just the ability to survive and overcome crisis, but also the willingness to explore new solutions, such as promoting unique solutions, social ties and student community, gamification, and managing anxiety.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

6. Conclusion

In conclusion, our study on the factors influencing students' online learning experiences during the COVID-19 pandemic in France sheds light on crucial aspects that impact the effectiveness of online education. The investigation focused on the student point of view, addressing key elements such as access to technology, the value of learning, facilitating conditions, and behavioral intentions. Facilitating conditions and learning value emerged as pivotal factors positively affecting online learning, suggesting a potential acceptance of online engagement even beyond the pandemic. Our findings also revealed variations in learning values across different education levels, with graduate students exhibiting higher values. The study underscored the significance of educational and technical support from institutions in enhancing the overall online learning experience. The research aligns with the CCPT framework and the Connectivism theory. Moreover, the study explored that maintaining and strengthening social ties through digital interactions played a key role in improving students' resilience during COVID-19. Students were forced to draw on external resources (peers, teachers and educational teams) to alleviate stress and build resilience.

For future work, it is imperative to delve deeper into the identified factors influencing students' online learning experiences, extending the research to encompass diverse cultural contexts and educational settings. Conducting longitudinal studies to track the evolution of attitudes and behaviors over time would provide valuable insights into the sustained impact of online learning. Additionally, exploring the effectiveness of specific interventions, such as tailored educational tools and targeted professional development for teachers in ICT and pedagogy, could offer practical solutions to enhance the overall online learning landscape. Further investigation into the socio-economic factors affecting accessibility and the development of strategies to bridge these gaps will be crucial for ensuring equitable educational opportunities. Finally, as the field of online education continually evolves, ongoing research should remain adaptive, integrating emerging technologies and innovative pedagogical approaches to address the dynamic challenges and opportunities in the ever-changing landscape of digital learning. While our study provides valuable insights, it is not without limitations. The research primarily focused on the French context, and findings may not be universally applicable. Additionally, the study's reliance on self-reported data could introduce response biases. Future research should consider diverse cultural contexts and employ a mix of qualitative and quantitative methodologies for a comprehensive understanding of online learning experiences. In conclusion, the COVID-19 pandemic has accelerated the need for innovative approaches to education. Addressing the identified challenges and leveraging the opportunities will be pivotal in shaping a resilient and effective online learning landscape for the future.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Almaiah, M. A., Al-Khasawneh, A., & Althunibat, A. (2020). Exploring the critical challenges and factors influencing the E-learning system usage during COVID-19 pandemic. *Education and Information Technologies, 25*, 5261–5280.

Barret, C. B., Ghezzi-Kopel, K., Hoddinott, J., Homami, N., Tennant, E., Upton, J., Wu, T. (2021). A scoping review of the development resilience literature : Theory, methods and evidence. *World Development*, vol. 145 : https://doi.org/10.1016/j.worlddev.2021.105612

Davis, F. D. (1986). A *technology acceptance model for empirically testing new end-user information systems : Theory and results.* Massachusetts Institute of Technology.

Fisher, D. M., Ragsdale, J. M., Fisher, E. C. S. (2019). The Importance of Definitional and Temporal, Issues in the Study of Resilience. *Applied Psychology : An international review,* 68 (4), 583–620. doi: 10.1111/apps.12162

Ho, N. T. T., Sivapalan, S., Pham, H. H., Nguyen, L. T. M., Van Pham, A. T., & Dinh, H. V. (2020). Students' adoption of e-learning in emergency situation : the case of a Vietnamese university during COVID-19. *Interactive Technology and Smart Education, 17*(4), 1–24. https:// doi. org/ 10. 1108/ITSE- 08- 2020- 0164

Ibrahim, R., Leng, N. S., Yusoff, R. C. M., Samy, G.N., Masrom, S., and Rizman Z. I. (2017). E-learning Acceptance Based on Technology Acceptance Model (TAM). *Journal of Fundamental and Applied Sciences*, Vol. 9 No. 4S, Special Issue.

Mailizar, M., Burg, D., & Maulina, S. (2021). Examining university students' behavioural intention to use e-learning during the COVID-19 pandemic : An extended TAM model. *Education and Information Technologies,* 26, 7057–7077. https://doi.org/10.1007/s10639-021-10557-5.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge : A new framework for teacher knowledge. *Teachers College Record,* 108(6), 1017-1054.

Mohammadi, H. (2015). Investigating users' perspectives on e-learning : An integration of TAM and IS success model, *Computers in Human Behavior*, Volume 45, April, Pages 359-374.

Rafique, H., Almagrabi, A. O., Shamim, A., Anwar, F., & Bashir, A. K. (2020). Investigating the acceptance of mobile library applications with an extended technology acceptance model (TAM). *Computers & Education*, *145*, 103732.

Scherer, R., Siddiq, F., Tondeur, J. (2019). The technology acceptance model (TAM) : A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, Volume 128, January, Pages 13-35.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Shumaila, Y., Yousafzai, Gordon R. Foxall, John G. Pallister (2007), Technology acceptance: a meta-analysis of the TAM: Part 1, Journal of Modelling in Management , ISSN: 1746-5664.

Siemens, G. (2004). Connectivism : A learning theory for the digital age. Elearnspace.

Siron, Y., Wibowo, A., & Narmaditya, B. S. (2020). Factors affecting the adoption of e-learning in Indonesia : Lesson from Covid-19. *JOTSE: Journal of Technology and Science Education, 10*(2), 282–295.

Sukendro, S., Habibi, A., Khaeruddin, K., Indrayana, B., Syahruddin, S., Makadada, F. A., & Hakim, H. (2020). Using an extended Technology Acceptance Model to understand students' use of e-learning during Covid-19 : Indonesian sport science education context. *Heliyon, 6*(11), e05410.

Venkatesh, V., and Davis, F. D. (2000). A theoretical extension of the technology acceptance model : four longitudinal field studies. *Manage. Sci.* 46, 186–204. doi: 10.1287/mnsc.46.2.186.11926

Vladova, G., Ullrich, A., Bender, B., & Gronau, N. (2021). Students' Acceptance of Technology-Mediated Teaching–How It Was Influenced During the COVID-19 Pandemic in 2020 : A Study From Germany. *Frontiers in Psychology, 12*(1), 1–15. https:// doi. org/ 10. 3389/ fpsyg. 2021. 636086.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Innovating for a sustainable future

Mónica María González Cabrera

Department of Vocational Training Education, IES Federica Montseny, Burjassot, Valencia, Spain

Abstract

The educational experience called "Innovating for a sustainable future" is being developed in the 2023-2024 academic year through a Hackathon. This practice is planned for students in the second year of Higher Vocational Training at the Federica Montseny Secondary School in Burjassot, Valencia. The Hackathon is carried out in two different shifts, one in the morning and the other in the afternoon, so that it can be carried out by all the target students, depending on their study timetable. For the teaching and learning experience, participants are grouped into multidisciplinary teams, who are asked the question: "How can we improve the sustainability of the Institute?" Through the application of the Design Thinking methodology, the working groups design possible solutions to the challenge posed. The development of the proposals is carried out in different phases, consisting of empathising, defining and devising, prototyping and validating. The jury, made up of experts in sustainability and the environment, determines the best solutions to the challenge posed based on the evaluation rubric. The results of this project show that the project itself has contributed to the development of certain skills that enhance the students' creativity when solving problems, an aptitude that can be adapted to their future working environments to face the different challenges they face.

Keywords: Hackathon; Design Thinking; sustainability; entrepreneurship.

How to cite: González Cabrera, M. M. (2024) Innovating for a sustainable future. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. xxx-xxx. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The teaching and learning experience consists of a Hackathon, which can be defined as an endurance race where the winner is the one who offers the best solution to a challenge (Vivanco-Galván et al., 2018). Therefore, students must use skills such as leadership, time management and communication, among others, to tackle a challenge with limited resources and time in the most creative, realistic and effective way possible. In short, the use of the so-called soft skills is essential to solve the challenge they face. Through this experience, the aim is to promote among students the development of these competences that are currently in demand in the workplace (Villalobos, A.M and Corrales, E.C, 2023).

For the development of this educational practice, it has been decided to use the Design Thinking methodology. This is a pedagogical strategy based on collaborative work and experimentation. Students must investigate the main problems to be addressed, analyse the beneficiary of their proposal in detail and empathise with their real needs in order to find an innovative and creative solution to the challenge posed. This way of reasoning and acting, in which new ideas and approaches must be provided to face a specific challenge existing in the changing reality of today's world, fosters an entrepreneurial attitude and spirit (Mercedes et al., 2017), a highly valued skill in today's business environments (Amabile, T. M., 2018).

Likewise, through this educational experience, the aim is to contribute to the environmental education of students in order to promote the sustainable social development of citizens (Luna-Nemecio, 2019). Therefore, the challenge to be addressed is to realistically propose an achievable solution to: "How to improve the sustainability of the Institute". The chosen methodologies require the active participation of the students, which implying that they must analyse in detail the current situation, investigate different possibilities to prosper and propose an alternative way to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

In short, the Hackathon aims to achieve the following objectives: 1. To promote the development of skills that contribute to the employability of students. 2. To develop the ability to provide a solution to a problem with limited resources and time. 3. To foster an entrepreneurial culture. 4. To make students aware of the importance of being active agents in the sustainability of the planet.

2. Justification

The educational practice described here is implemented at IES Federica Montseny. This educational centre is a public secondary school, located in the town of Burjassot, in the metropolitan area of the city of Valencia. It houses students of Compulsory Secondary Education (ESO), Baccalaureate, Basic Vocational Training and Vocational Training Cycles of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

intermediate and higher grade of 6 different Professional Families: Commerce and Marketing; Electricity and Electronics; Installation and Maintenance; Mechanical Manufacturing; Health and Safety and Environment. This centre is home to approximately 1400 students, of which around 80% are studying in Vocational Training.

One of the objectives of IES Federica Montseny is to foster an entrepreneurial culture among its pupils, a purpose that is exercised through the application of active methodologies that help to promote skills such as creativity, innovation and the development of so-called "soft skills" among students. In addition, in order to achieve this goal, this school is part of the Emprén programme promoted by the Department of Education of the Generalitat Valenciana, which has allowed it to create an entrepreneurship classroom with the aim of promoting entrepreneurial cultural experiences.

Emprén, together with Acredita, Innovatec and Qualitas, is one of the programmes that form part of the Novigi Network. This collaborative network between teachers in this field and vocational training centres, aspires to promote pedagogical and organisational innovation, favouring active methodologies in which students take an active role in the process of acquiring competences (Conselleria de Educación, Universidades y Empleo de la Generalitat Valenciana (Novigi - Formación Profesional - Generalitat Valenciana, n. d. Novigi - Formación Profesional - Generalitat Valenciana (gva.es).

It is also important to mention that IES Federica Montseny is an educational centre that is particularly committed to caring for the environment. It has carried out sustainability actions focused on the following 5 main areas: improvement of energy efficiency in the centre (installation of photovoltaic panels, change of luminaires, sectorising lighting, installation of timers in the classroom computers, control of heating and control of electricity and gas consumption); control and reduction of water consumption (control of consumption, installation of taps with sensors, control of watering the vegetable garden); waste management (separate collection of paper/cardboard, packaging, toners, batteries, metals, wood, electrical appliances and toxic waste); promotion of biodiversity (garden with native plants, insect huts); and awareness-raising (awareness-raising among teachers, involvement of students in the school's sustainability projects, participation in sustainability-related competitions, celebration of health day, and reflection on the SDGs). In addition, a committee has been set up consisting of a group of teachers in charge of ensuring that sustainability is improved at the school and whose main functions are to propose the actions to be carried out annually, to review and ensure that the measures implemented are effective, and to promote and encourage sustainability at the school.

In short, following the centre's strategic lines, this teaching and learning experience is designed, on the one hand, to foster an entrepreneurial culture among students, a purpose that is exercised through the application of active methodologies that help to promote skills

BY-NC-SA 2024, Editorial Universitat Politècnica de València

such as creativity, innovation and the development of the so-called "soft skills" among students. And, on the other hand, to raise students' awareness of the importance of living in a way that is compatible with the sustainability of planet Earth, an aim that is intended to be promoted by encouraging students to work proactively, analysing the current reality, investigating different possibilities for prosperity and reflecting on innovative ways of contributing to this progress.

3. Development

3.1 Participants

- **Faculty**

The teaching and learning experience described has been planned and implemented by the members of the Emprén commission of the IES Federica Montseny de Burjassot. It is a multidisciplinary team of ten members, with the presence of teachers from all the professional families taught at the school (health; commerce; electricity and electronics; maintenance and chemistry and environmental health), and teachers from the Department of Training and Work Orientation who, due to the subjects of their didactic competence, are more closely linked to entrepreneurship.

It should be mentioned that, in addition to planning and organising the teaching and learning experience, during the Hackathon, the teaching staff acts as a guide for each of the participating groups, resolving any doubts that may arise during the development.

- **Alumni**

The Hackathon has been planned for all students who are in the 2nd year of one of the Higher Level Training Cycles taught at the school.

In the morning shift, these Training Cycles are: Telecommunications and Computer Systems; Dietetics; Clinical Electromedicine and Chemistry and Environmental Health.

And, in the afternoon, these are: Dietetics; Industrial Mechatronics; Industrial Automation and Robotics; Prosthetic Audiology and International Trade.

- **Jury**

In order to determine the winning proposals for the educational practice described here, experts in sustainability and the environment were present.

In the Hackathon held in the morning shift, the Jury was composed of: two employees of Argano Asesores, a Valencian company that offers consultancy services specialising in the Environment; the Councillor for the Environment of Burjassot City Council and the energy efficiency coordinator of the IES Federica Montseny.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Jury was composed of the same members for the Hackathon held in the afternoon, except for the Councillor for the Environment of Burjassot City Council, who was replaced by the Principal of IES Federica Montseny.

3.2 Programme

The Hackathon was carried out at two different times. It has been structured in this way due to the organisers' interest in adapting to the particularities of the educational centre where the educational practice has been implemented. The school has a morning and afternoon timetable and, therefore, in order to ensure the possible attendance of all the expected students, it was decided to carry out the educational experience in both time slots.

However, in both shifts, the programme was as follows:

Table 1 – Hackathon schedule

Duration	Task
45 minutos	Inauguration, explanation of the challenge and team formation
120 minutos	Teamwork to solve the challenge
30 minutos	Lunch break
60 minutos	Preparation of the oral presentation
90 minutos	Presentation of solutions to the jury
15 minutos	Prize-giving, farewell and closing ceremony

Source: Own elaboration

3.3 Phases

The teaching and learning experience materialised through the Hackathon is developed in different steps, which are specified below:

- **Phase 0. Inauguration, explanation of the challenge and formation of teams**

In this phase, the students are received in the multi-purpose room of the centre to welcome them. Once all the participants are present, the educational practice that is going to be carried out is explained to them, starting with a description of the current problems with regard to the sustainability of planet Earth. Next, reference is made to the Sustainable Development Goals established in 2015 by the United Nations General Assembly, which are intended to be achieved by 2030 and aim to "achieve a better and more sustainable future for all", United Nations (2017).

After raising the students' awareness of the vital need for all citizens to be active agents of a change of mentality and lifestyle that guarantees the conservation of the environment in which we live, they are presented with the challenge to which they must respond during the day. Specifically, the students' challenge consists of realistically proposing an achievable

BY-NC-SA 2024, Editorial Universitat Politècnica de València

solution on: "How to improve the sustainability of the Institute". In order to ensure that the suggested proposals are innovative and can be implemented at the school, all the actions that the Institute is already carrying out are listed.

To begin the teaching and learning experience, the organisers of the Hackathon proceeded to group the students into teams. In each of the moments that the educational practice is carried out, the promoters of the activity have formed heterogeneous groups of a maximum of 6 participants. The purpose of this grouping was to create groups as complete as possible in terms of knowledge, skills and profiles.

- **Phase 1. Empathise**

In this first phase, the nature of the challenge is analysed: why is it being proposed? Why does it need to be solved? What are the current sustainability needs? What is going wrong that requires change? They will use empathy, research and observation to obtain valuable information about the real needs faced by the school. This phase consists of two stages:

– Step 1. Market research.

The aim is for students to find relevant data (through different blogs, articles, news or reports, among others) that indicate where they can act to improve the sustainability of a school.

– Step 2. Landing the challenge

It consists of students substantiating and defining the specific need(s) on which they will focus their solution.

- **Phase 2. Define/Ideate**

Once the students have identified the specific needs on which they will focus their solution, they should start to generate ideas and develop and define those possible solutions that can have the greatest impact on the sustainability of the school. This phase consists of:

– Step 1. Brainstorming

The students individually make different proposals and, once several alternatives have been put forward, each member of the group chooses the three they consider most appropriate. The most repeated options will be the ones to be developed in the following phases.

– Step 2. Landing the challenge

It consists of the students defining as specifically as possible the solutions they have selected. To support this task, the organisers provide participants with a fillable template with instructions on the aspects they should elaborate on.

- **Phase 3. Prototype**

In this phase, the aim is to develop and visualise the proposals that the students have put forward. In other words, to offer a demonstration of the solution through the creation of a prototype.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Artificial Intelligence tools are used to create an image that shows the product or service as clearly as possible and allows the added value to be appreciated. To facilitate this task, the Hackathon organisers provide the teams with a list of the most commonly used AI image creation tools (Craiyon, DALL-E 2, Leonardo.ai, Bing, Deep Dream Generator, Night Cafe Creator). However, students are free to use others if they prefer.

- **Phase 4. Validate**

This is the moment to check whether the students' solution to the problem is viable and impressive in the eyes of the jury. This phase consists of two stages:

– Step 1. Storyboard

This dynamic serves to make it easier for students to describe and define the essential ideas of the proposed solution in a brief and synthetic way, while capturing the attention of the listener. Only by generating the interest of the listener will they decide to spend time getting to know the idea in more depth.

– Step 2. Elevator Pitch

This consists of students preparing a short oral presentation (approximately three minutes) in which they manage, on the one hand, to convey the essential ideas of the solution developed. On the other hand, they have to make an impact on the jury with their proposal. To facilitate this task, the Hackathon organisers provide the teams with guidelines for the preparation of the speech.

Students are offered the possibility of producing a visual presentation to support their speech, but with the limitation that only images (no text) may appear in the presentation, and with a maximum of 6 images.

3.4 Results

- **Evaluation process**

At the end of the day, each group presents their solutions to the Jury through an Elevator Pitch. This form of oral presentation consists of presenting the key aspects of their idea in a limited amount of time, which would be the duration of a "lift conversation", being sufficiently convincing to capture the interest of the listener.

They also give the Jury an envelope in which the teams have compiled the work carried out in each of the phases: empathising, defining and devising, prototyping and validating.

The evaluation of the work done by the different groups participating in the Hackathon is carried out by the Jury. After each oral presentation, the members of the Jury take some time to reflect so that, on the basis of the evaluation rubric, they can quantify numerically the quality of the work carried out by each team.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- **Evaluation rubric**

The organisers of the educational activity provide the jury with an evaluation rubric, so that they can quantitatively and qualitatively determine the best solutions to the challenge posed. The decision is made by scoring the quality of the work carried out by the groups in each of the phases of the Hackathon numerically and on the basis of the observation of the oral presentation of the solutions. This way of measuring the results aims to guarantee the objectivity and equality of the criteria used to evaluate the solutions presented.

It is important to mention that, prior to the Hackathon, the Jury had been provided with the evaluation rubric. This allows them to familiarise themselves with each of the criteria that will be taken into account in the evaluation process.

- **Criteria used for evaluation.**

PHASE 1. EMPATHISE

- Degree of identification of the characteristics and needs of the beneficiary of the proposal (educational centre) in order to be able to offer a personalised solution.
- Degree of identification of the problem to be solved (provide relevant data: articles...).

PHASE 2. DEFINE/IDEATE

- Degree of definition of the solution they propose to the problem detected (they provide articles, news, reports... that support the suitability of the solution).
- Degree of detail in which they cite the benefits to the Institute of the value proposition they propose for the proposed solution.
- Degree of feasibility and level of creativity of the proposed solution.
- Relation of the idea to the SDGs.

PHASE 3. PROTOTYPING

- Extent to which the prototype created with AI shows the main features and functionalities of your proposal.

PHASE 4. VALIDATE

- Degree of clarity in organising the information presented in your elevator-pitch
- Correct use of oral expression
- Correct use of non-verbal language
- Degree of attraction of the listener's interest
- Use of visual aids (to support the speech without stealing the message)

- **Winning proposals**

In the morning Hackathon, the winning team proposed to replace the school's drinking water fountains with osmosis fountains with a pay-as-you-go dispenser. The price would be

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

symbolic in order to promote responsible water consumption. This solution aims to address the excessive use of plastic bottles by encouraging members of the educational community to use their own reusable containers.

In the afternoon Hackathon, the winning team proposed utilizing the empty spaces on the roofs and walls of the Institute to implement gardens and green areas, which would increase the thermal and acoustic insulation of the buildings. This is intended to combat the high temperatures inside the classrooms which, with climate change, are increasingly being experienced for longer periods of the year. This affects students' concentration levels and leads to a decrease in their academic performance.

4. Conclusions

At the end of the Hackathon, the experience was evaluated by means of two evaluation surveys, one addressed to the participating students and the other to the members of the Emprén Commission, the organisers of this educational initiative.

The students' responses show that, after the Hackathon, they are more aware of the environmental problems that exist in our surroundings and are more aware of the need to favour a lifestyle that ensures the survival of natural in order to protect the well-being of future generations. In addition, they say that the use of methodologies that require their active participation to respond to a challenge with limited time and resources increases their motivation and involvement.

Furthermore, the members of the Emprén commission state that, during the activity, they have been able to observe how the students have used skills such as leadership, teamwork, time management, creativity and communication, among others, to overcome the challenge in the most satisfactory way possible. They also highlight the good predisposition of the students during the whole educational practice.

Therefore, based on the results obtained in the student and teacher assessment surveys, the following conclusions can be drawn:

- The use of agile methodologies activates student motivation.
- It has contributed to promoting the employability of students through the development of soft skills that enhance creativity in problem solving.
- The possibility of putting into practice the proposals put forward by the students as a school project, fostering an entrepreneurial culture among the participants.
- Analysing the problems of the reality that surrounds us has made students aware of the importance of being active agents in the sustainability of the planet.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

The educational practice described here has been funded by the Regional Ministry of Education, Culture and Sport of the Valencian Community. This body, within the Plan for Recovery, Transformation and Resilience funded by the European Union, provides public centres attached to the Emprén programme, which have complied with the procedures established in the RESOLUTION of 5 July 2023, of the Directorate General for Vocational Training and Special Regime Education, with a financial allocation consisting of 5,000 euros for the year 2023.

Conflicts of interest

The author declares that he has no known competing financial interests or personal relationships that could have influenced the work presented in this article.

References

Amabile, T. M. (2018). Creativity in context: Update to the social psychology of creativity. Routledge.

Comisión Mundial sobre Medio Ambiente y Desarrollo. (1987). Nuestro futuro común. Oxford University Press.

Miller, D. (2021). Marketing simple. Urano.

Novigi - Formación Profesional - Generalitat Valenciana. (s. f.). Formación Profesional. https://ceice.gva.es/es/web/formacion-profesional/novigi

Luna-Nemecio, J. (2019). The importance of environmental education to achieve Sustainable Social Development. (Dossier Presentation) [La importancia de la Educación ambiental para lograr el Desarrollo Social Sostenible. (Presentación del Dossier)]. Ecocience. International Journal, 1(1), 6-11 .doi: dx.doi.org/10.35766/je19111

Mercedes, P. A., Germán, R. G., & Marcela, L. P. L. (2017). Emprendimiento y creatividad: Aspectos esenciales para crear empresa. Ecoe Ediciones.

United Nations (2017). Resolution adopted by the General Assambly on July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313 Archived October 23, 2020 at the Wayback Machine). A/RES/71/313 - E - A/RES/71/313 (archive.org)

Villalobos, A. M., & Corrales, E. C. (2023). Importancia de las habilidades blandas en los entornos laborales: Importance of soft skills in work enviroments. *LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades*, *4*(3), 1076-1087.

Vivanco-Galván, O., Castillo, D., & Jiménez-Gaona, Y. (2018). HACKATHON Multidisciplinario: Fortalecimiento del aprendizaje basado en proyectos. Revista Electrónica Calidad en la Eucación Superior, 9(1), 119-135. https://doi.org/10.22458/caes.v9i1.1893

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Field classes in accounting as a "Black Swan" of sustainable education

Piotr Szczypa[a], Magdalena Majchrzak[a]

[a]The College of Economics and Social Sciences, Warsaw University of Technology, Poland

Abstract

For a long time, teaching accounting has mainly focused on active forms of conducting classes in which the student must be involved. Nowadays, this approach should be considered insufficient. Additionally, one should read the guidelines from almost a hundred years ago, when the educational values of accounting and the role of the teacher in the teaching process as both a pedagogue and a practitioner were strongly emphasized. Taking into account the above-mentioned premises, the authors have conducted a teaching experiment over the last 20 years consisting in organizing field classes (outside the university building) in the field of teaching accounting. Such classes initially lasted from a few hours to currently three days. The aim of the article is a multi-aspect assessment of conducting field classes in accounting. The research was carried out using the following methods: literature analysis, document analysis, diagnostic survey (interviews with teachers and students before and after field classes); participant observation. The research results gave unexpected conclusions and showed the achievement of a synergy effect that had not been previously assumed. The whole thing can be described as a "Black Swan" of sustainable accounting education. Similarly to the case of the "Black Swan" phenomenon, when assessing field classes in accounting, not only the didactic values were pointed out, but also the analysis of risk, uncertainty, randomness in relation to accounting and students' personal lives. The inherent opacity and unpredictability of accounting field classes provided a new, larger space for organizing sustainable education. The conclusions from the conducted research constitute a premise for extending this teaching method to other subjects as well as modifying previous assumptions for the sake of sustainable education.

Keywords: sustainable education; Black Swan; teaching accounting; field classes.

How to cite: Szczypa, P. and Majchrzak, M. (2024) Field classes in accounting as a "Black Swan" of sustainable education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 493-500. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Mattessich (2000) presented evidence that accounting as we use it today (double entry rule) was already used by the ancient Sumerians around 3200 BC. Therefore, there was already a need to teach accounting. One of the oldest written works dedicated to teaching accounting that is widely known is "Summa de Arithmetica, Geometria, Proportioni et Proportionalita" by Luca Pacioli. However, only the 20th and 21st centuries provide numerous publications on accounting education. One of the dominant topics were accounting teaching methods. Similarly to Janowicz (2007), numerous authors refer in this respect to the process of people remembering. In the most general terms, we remember: 10% of what we hear; 20% of what we see; 30% of what we talk about and as much as 90% of what we do. This is reflected in the effectiveness of teaching methods. Taraszkiewicz (2000), using Dale's cone ("memorization pyramid"), indicates the percentage effectiveness of memorization in various teaching methods, namely: lecture - 5%; reading – 10%; audiovisual methods – 20%; demonstrations – 30%; discussion groups – 50%; practice through action – 75%; teaching others (immediate use of acquired knowledge) – 90%. Additionally, in recent years, like Rydzewska, Nadolna (2022), attention has been directed to the issue of remote teaching of accounting due to the COVID-19 pandemic. The issue of teaching accounting should not be limited only to methods of transmitting knowledge and skills. By teaching accounting, we also educate and shape the student's personality and profile in accordance with broadly understood social competences. This issue was already emphasized in 1933 by Tomanek (1933), whose words should be mentioned here because they became one of the premises for implementing a didactic experiment involving the organization of field classes in accounting. Tomanek (1933) states: "If we were to summarize the educational values of accounting and list them together, it would be necessary to say that accounting develops in a person: diligence, meticulousness, love for law and order, develops the ability to orient, classify phenomena, examine, evaluate and criticize them. , develops work planning, calculation and combinatory sense, develops a sense of criticism, responsibility and civil courage, and finally organizational skills. When teaching accounting, we must try to develop these and similar values in young people, expand and deepen them, that is, through accounting, we must develop in young people a healthy economic worldview, or in other words, "smartness in life" in the positive sense of the word.

Taking into account the guidelines regarding the effectiveness of accounting teaching methods and its educational values, a decision was made to implement a teaching experiment. The experiment consisted in organizing field classes as a form of teaching accounting. Its aim was to effectively teach accounting (knowledge and skills) and to convey educational values through teaching accounting (social competences). The aim of the article

2024, Editorial Universitat Politècnica de València BY-NC-SA

is a multi-aspect assessment of conducting field classes in accounting as part of the authors' many years of experience.

2. Material and methods

The research concerned actually conducted field activities as a form of teaching accounting. In the years 2003-2013, field classes were carried out as an additional form of teaching accounting at the University of Szczecin at the Faculty of Management and Economics of Services, and from 2017 as a form of practical classes in the field of finance and accounting included in the study program at the Academy of Applied Sciences in Konin. As part of the implementation of the goal, it was assumed that the research process would consist in confronting the didactic assumptions included in the subject description sheet and the literature guidelines on the subject with the opinions and effects of students and teachers participating in the above-mentioned studies. classes.

The research was qualitative in nature. They were conducted using the diagnostic survey method. An interview technique was used. The research tool was an interview questionnaire prepared separately for two groups of respondents: students and teachers. Therefore, the selection of the sample was purposeful. Interviews were conducted in 2022 and 2023 before and after field activities. In addition, the following complementary research methods were used: literature analysis (to place the article in the context of didactics theory), document examination (study program, course descriptions), and participant observation as part of the active experiment method. Therefore, the research was of a registration and observational nature. When analyzing the data, special attention was paid to the most frequently indicated answers and those that were not obvious.

3. Results

3.1 The idea and assumptions of field classes in accounting

Field classes in accounting are included in the first-cycle study program in the field of practical profile "finance and accounting". They are carried out in the fourth semester as part of the subject "finance and accounting workshops". This subject takes place only as part of practical classes: 10 hours of project classes and 15 hours of training classes and camps. The general concept of this subject assumes:

- as part of project classes, consolidation and updating of knowledge and skills necessary in the work of an accountant;
- as part of field classes, carrying out a large, complex task related to one settlement period of a selected enterprise; task performed by groups of students (team work) of 3-4 people; the workload of the task is approximately 20 hours, which includes: completing selected

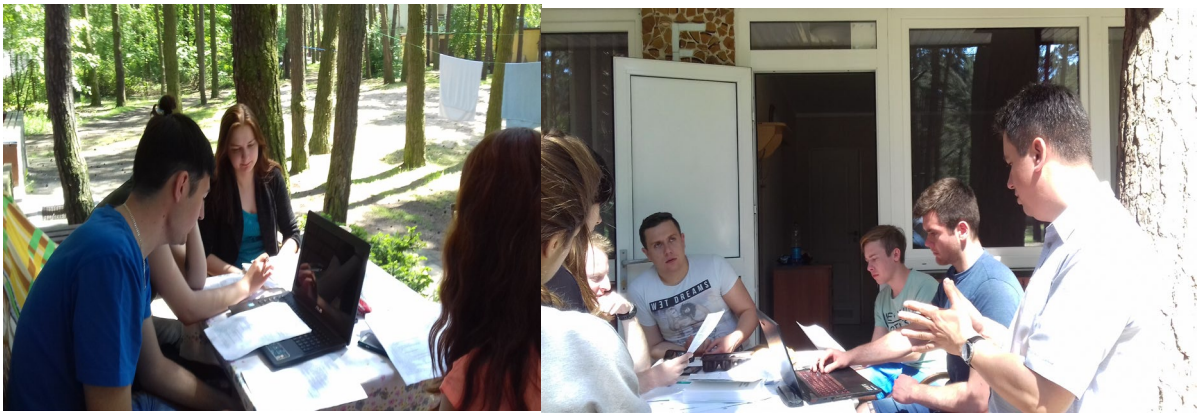
BY-NC-SA 2024, Editorial Universitat Politècnica de València

accounting documents (e.g. payroll, depreciation table, settlement of business trip expenses), posting on general ledger accounts and subsidiary books, valuation of selected economic categories, determining the financial result, preparation of financial statements, calculation and interpretation of selected financial ratios; students have the right to use all available sources of information; field classes take place outside the university walls in a place chosen by students and last a total of 3 days;

- obtaining funding for students' travel; conducting mini tenders and business talks to select the best accommodation offer and convenient conditions for group work; ensuring that students ensure documentation and settlements between the university and the selected recreation center where field classes will be held;
- student integration; work in various conditions and under time pressure; individual and team responsibility by assigning to each member of the work group a percentage of the level of work involvement that affects the grade assigned by the teacher.

In Fig. 1 you can see the work of students in groups during field classes in accounting, including during discussions with a teacher who is also a statutory auditor and chief accountant in a large transport company.

Fig. 1 – Field activities in the recreation town of Ślesin



Source: authors' private resources

3.2 Field activities in the opinion of teachers

A comprehensive description and evaluation of the field activities carried out in 2023 were presented by Cieciura (2023) in the university magazine. Teacher's report: "The classes were conducted from May 10 to 12 in one of the centers in Ślesin. Second-year students had to complete many tasks that allowed them not only to consolidate their specialist skills, but also to acquire social competences. The youth's task was, among others, selecting the recreation center where they would like to organize these activities, taking into account the amount allocated by the rector (review of offers, calculation of unit costs, checking the accommodation conditions in a given center, price negotiation, etc.); implementation of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

extensive tasks in the field of finance and accounting in project groups (recording business operations, preparing documentation, preparing financial statements, elements of financial analysis, etc.); financial settlement with the owner of the center, checking the correctness of the issued invoice, settlement of the funds used with the university. The students performed all the tasks assigned to them very well. The first day (actually the evening) was spent talking around the fire and roasting sausages. On the second day, they worked intensively on the design task in previously formed groups of 4-5 people. As a result, five projects were created. An additional educational aspect of this year's field trip was the meeting of students with the academic class invited to Ślesin. The students provided students with information about the most important tasks that they had to perform themselves as part of organizing field activities. The natural surroundings and weather were beautiful, and the atmosphere and spirits were good. In my opinion, as a person conducting the course, this form of classes has many advantages - it allows you to consolidate acquired skills, shapes attitudes and social competences, gives room for negotiations, teaches team work and work time organization. An invaluable and very important aspect of this form of classes is also the integration of the student community."

In the opinion of four other teachers who participated in field classes in the period before and after the COVID-19 pandemic, the following conclusions were most often reached regarding this form of educating students in the field of accounting:

- group of conclusions no. 1 - student behavior: an excellent form of student integration; they finally moved beyond cell phones; they really got to know each other;
- group of applications no. 2 - learning the profession of an accountant or financier: this form of classes allows for a comprehensive look at accounting; great practicality; they must cooperate as in a company; are responsible for their decisions; they learn from mistakes.

In addition, a non-obvious situation was also pointed out that occurred at the stage of agreeing and documenting the financial settlement between the recreation center chosen by the students and the university. It turned out that the owner of the center used net amounts (excluding VAT) during the negotiations, and only when they received the invoice for payment did the students realize that the amount to be paid was higher (by the amount of VAT) than the one they considered to be the target. This unforeseen situation became an excellent lesson in learning from mistakes and showed that knowledge in the field of settlements and taxes resulting only from lectures does not have to be effective in real conditions. Ultimately, the students did not suffer financial consequences and the university increased the amount of funding. The unexpected effects also included: a noticeable simultaneous concern for private finances and the environment when students agreed on

BY-NC-SA 2024, Editorial Universitat Politècnica de València

how to get to the center (maximizing car occupancy; choosing public transport); preparing meals together; care for cleanliness in the facility.

An unexpected effect of this form of classes, thanks to the "additional" meeting of students in conditions other than those at the university, was the offer of a job at the university. This situation occurred over 10 years ago, and currently the people recruited in this way already have a Ph.D.

3.3 Field activities in the opinion of students

Before leaving, the students articulated on the website:

- disadvantages: risk related to the composition of the group for the purpose of solving the task; the risk of whether they will be able to cope with such a large task, since at the university they only performed random accounting work; who will I live with;
- advantages: three days away from the university, with no other activities.

The above statements are an expression of behavior typical of school youth, not academic ones. However, after completing field activities, students pointed out:

- group of applications no. 1 - task performance: high workload; even the smallest mistake can have serious consequences; it takes a lot of time to find the error; only now I see what accountants actually do;
- group of conclusions no. 2 - time management, interpersonal relations: it's great that we had a bonfire and roasted sausages; it was only during the trip that I met all the people with whom I study together; it was interesting to spend time with teachers in a different setting.

Students also pointed out unexpected situations, such as: a faulty water heating system in one of the houses; damaged bathroom door; three-hour disconnection from electricity. Moreover, they expressed their appreciation for selected colleagues who took personally prepared dishes and cakes with them for the trip.

4. Discussion

The collected opinions expressed by teachers and students in relation to assumptions regarding knowledge, skills and social competences regarding the subject implemented in the form of field classes can be divided into two groups:

- opinions consistent with the assumptions, consistent with the objectives of the subject;
- non-standard, unexpected, non-obvious opinions.

In the authors' opinion, these non-standard effects of field activities can, to some extent, be compared to the term "Black Swan" used in economic sciences. It means an unexpected event that no one can predict. These types of events often have a huge impact on the world and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

negatively impact the economy and society. Here, in the context of the studied classes relating to microspace, one selected university cannot be directly referred to such a "Black Swan" idea. However, within these local conditions, one can see to some extent the senselessness and untrueness of predictions based on past experience. Moreover, unexpected events shown in research also have (or perhaps primarily) positive consequences. Therefore, the authors' use of the term "Black Swan" is more humorous and is also a marketing solution.

The presented approach of the authors led to the non-obvious observation that the concept of field classes in accounting enabled the implementation of sustainable education. It happened in a natural, grass-roots way, not initiated by teachers or students. This didactic phenomenon, which engaged heads, hearts and hands, should be appreciated even more. Learning occurred on three levels: cognitive, social-emotional, and behavioral. In keeping with the academic terminology, it can be said that field studies in accounting provided students with knowledge, skills and social competences in the field of accounting within the framework of the idea of sustainable development, which shows respect for the line between man, money and the environment, while at the same time students acquired the educational values given by Tomanka (1933).

5. Conclusions

Report of field classes in accounting:

1. Facilitates the achievement of educational and didactic values.
2. It is conducive to achieving not only the expected effects, but also non-obvious ones such as the "Black Swan" symbol.
3. It provides a platform for implementing sustainable education.
4. It is a motivator for implementing the concept of field classes as part of some other subjects. An example here is the organization of workshop classes on management accounting in the Leroy Merlin store in Konin (classes conducted by the store director; students prepare cost accounting in real conditions) and classes on the organization of an accounting office carried out partly in an accounting office owned by a teacher of a given subject.

Research will continue to examine the long-term impact of the proposed teaching methods and further develop the theoretical framework. In the future, the applicability of this approach in different educational contexts and at other universities will also be explored.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

The publication was financed by the financial resources of the College of Economic and Social Sciences of the Warsaw University of Technology.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Cieciura, M. (2023). Nauka, projekty i ognisko, "Szkiełkiem i Okiem" nr 3 (31), s. 39.

Janowicz, M. (2007). Metody aktywizujące w procesie nauczania. [w] Dydaktyka w naukach ekonomicznych, (red.) T. Kiziukiewicz, Katedra Rachunkowości Akademii Rolniczej w Szczecinie, Szczecin, s. 77-84.

Mattessich, R. (2000). Archaology of Accounting and Schmandt-besserat's Contribution, [w] The History of Accounting, (red.) J.R. Edwards, tom II, Routledge, London and New York, p. 5-6.

Rydzewska, M., Nadolna, B. (2022). Metody nauczania rachunkowości w warunkach zdalnego kształcenia w opinii studentów i nauczycieli – wyniki badań. [w] Metody nauczania rachunkowości, (red.) W. Gos, B. Sadowska, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin, s. 69-86.

Taraszkiewicz, M. (2000). Jak uczyć lepiej?, OCDN, Warszawa, s. 87.

Tomanek, F. (1933). Zarys metodyki nauczania rachunkowości podwójnej, Skład Główny w Księgraniach S.A. Książnica-Atlas w Warszawie i Lwowie, Warszawa, s. 13.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Education for Sustainable Development in Baltic Universities

Dina Bērziņa
Institute of Atomic Physics and Spectroscopy, University of Latvia, Latvia

Abstract

The paper reflects on the contribution of Baltic (**Estonia**, **Latvia**, **Lithuania**) universities towards the education for sustainable development. The study is centred at universities, which participate in the Times Higher Education (THE) and the Quacquarelli Symonds (QS) sustainability rankings, their own Sustainable Development Goals (SDGs) and curricula containing sustainability issues.

The Baltic countries are on track in the implementation of the UN SDGs. Part of the universities have set their own SDGs; others include them in the university's strategy.

The methodology is based on open-access information which can be found on university websites. Publicly available information on sustainability issues in tuition is varied and depends on country/institution. When this study does not reflect on any university's SDGs and/or curricula including sustainability issues, it means – data were not found (both English and national language) rather than they do not exist.

Estonian universities up till 2023 have not participated in THE Impact rankings (THE Impact edition of 2024 will be published after submission of this paper, in June 2024), and only two of them can be found on QS Sustainability rankings. Latvian universities are in the process of consolidating and merging faculties and study courses before 2024-2025 academic year is launched.

Keywords: Baltic countries; world university rankings (WUR); sustainable development goals (SDG); education for sustainable development (ESD); study programmes.

How to cite: Bērziņa, D (2024) Education for Sustainable Development in Baltic Universities. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 501-509.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

United Nations (UN) Sustainable Development Goals (SDGs) targeted at creating prosperity for people and planet now and into the future have been adopted by all UN Member States in 2015 (2030 Agenda).

The three Baltic countries Estonia, Latvia and Lithuania were founded in 1918, occupied by the Soviet Union in 1940 and re-gained independence in 1991. It explains the young age and relatively lower ranking of universities in comparison to the established European ones – majority were founded in 1920-ies or 1990-ies, with exception of the two 'old ones' in Vilnius and Tartu (Table 1).

Vilnius University (VU) is among the oldest universities in the Central Europe and was the easternmost university in Europe. Despite the existing university in Krakow at that time, many notable Poles are VU alumni, e.g.: Maciej Kazimierz Sarbiewski, Latin poet of the 17th century; Henryk Łowmiański, historian, researcher of the ancient history of Poland; Stefan Jędrychowski, deputy prime minister, foreign and finance minister in Poland (EduRank 2024).

University of Tartu (UT) is one of the oldest in the Northern Europe. UT has been special for Latvians before establishment of the University of Latvia. Some Latvian UT alumni in the 19th century: Krišjānis Barons, writer who systematised the Latvian folk songs; Eduards Veidenbaums, poet and translator; Alberts Kviesis, politician, and country's President 1930–1936. The way from Latvia to UT was expensive, some students made it on foot: K. Barons in 1859 and E. Veidenbaums in 1888 (Kursīte 2020). Today University of Tartu the leading one from Baltics in university rankings.

The oldest university in Latvia is Riga Technical University (RTU). Some notable RTU foreign alumni: Władysław Anders, Polish army general and member of the Polish government-in-exile in London; Ignacy Mościcki, Polish chemist and country's President 1926–1939; Paul Walden, German and Latvian chemist (EduRank 2024).

2. Sustainable Development in the Baltic region

2.1 National SDG targets

According to the SDR (2023) on the overall performance of the 193 UN Member States, top-performing countries are in EU+. Estonia ranks #10, Latvia – 14, Lithuania – 37. Estonia and Latvia are among the top-5 countries with the largest number of SDG targets on track. All Baltic countries have elaborated plans/strategies on the implementation of the 17 UN SDGs and submit Voluntary National Reviews (VNR) to the UN.

The direction for implementation of the SDGs in **Estonia** is integrated in the Estonia 2035 Strategy which sets out five long-term strategic goals for people, society, economy, living environment and governance (VNR EE 2020). **Latvia** is implementing the SDGs by

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

integrating them into the Sustainable Development Strategy of Latvia 2030 and National Development Plan for 2021-2027 (VNR LV 2022). **Lithuania** has elaborated Set of Recommendations for UN Sustainable development goals (VNR LT 2023).

2.2 Universities and sustainability targets

The two major university sustainability rankings are produced by the Times Higher Education, which assess universities against the UN 17 SDGs (THE 2023) and the Quacquarelli Symonds, which looks at the impact of research being done across the 17 SDGs (QS 2024 b). Table 1 depicts Baltic universities participating in the mentioned sustainability rankings and for comparison – independent EduRank (2024). Table 2 lists Baltic universities participating in THE Impact rankings.

Like the findings of Filho (2023), also for Baltic universities SDG1, SDG2, SDG6, SDG10, SDG15 are not necessarily a priority. In addition to the SDG4 which focuses on universities' contribution to lifelong learning, their research on quality education and commitment to inclusive education, Baltic universities are keen to engage on SDG3, SDG5, SDG8, SDG11, SDG16. Although Estonia is the front-runner for implementation of the SDGs, universities are not widely involved in the sustainability rankings. Below, university name abbreviations are used (for full names look Table 1).

Estonia. **UT** aims to achieve the SDGs in a research-based manner and resolve the challenges of the society: tackle global climate change, adapt to demographic changes, ensure security and safety, improve and promote human health, preserve biodiversity, govern the state smartly and reduce social gaps (SP UT). For Estonian universities **TalTech** and **TLU** the author could not find information linked to university's own SDGs.

Latvian universities have established Councils, which are responsible also for sustainable development of the university. SDGs of the **LU** were set in 2022 and targets are identified for all 17 SDGs (Table 2, marked with 'V') – the university promotes interdisciplinary research and education focused on knowledge and sustainable solutions, sustainable development, and quality of life in Latvia (SDG LU). **RTU's** SDGs are connected to the activities and/or projects conducted within RTU (SDG RTU). Among **RSU** priorities is achieving of the UN SDGs considering both the historical development of the university and its current strategic activities in medical education and research (SDG RSU). For Latvian universities **LBTU** and **TSI** the author could not find information linked to university's own SDGs.

Lithuania. **KTU** is integrating the 17 SDGs in all areas of its activity – the university aims to develop responsible future leaders and specialists in their areas and attempts to achieve long-term goals concerning well-being of people and environment (SDG KTU). **MRU** is engaged on all 17 SDGs and has elaborated Strategy for Sustainable Activities thus setting standards for sustainable activities in studies and research, infrastructure and landscape, sustainable

BY-NC-SA 2024, Editorial Universitat Politècnica de València

consumption and waste management, health, and social support (SSA MRU). **KU** will implement SDGs by organising inclusive and equal quality education and lifelong learning that enable society for sustainable development (PT KU).

Table 1 – Ranked Baltic universities

Name of the university / HEI – Short name (year of establishment)	THE rank		QS rank		EduRank
	Impact	WUR	Sustainability	WUR	
University of Latvia, Latvia – **LU** (1919)	101–200	1001–1200	695	801–850	998
Riga Technical University, Latvia – **RTU** (1862)[1]	301–400	1001–1200	771–780	751–760	1492
Riga Stradiņš University, Latvia – **RSU** (1950)[2]	201–300	1501+	X	901–950	4115
Latvia University of Life Sciences and Technologies, Latvia – **LBTU** (1936)[3]	801–1000	1501+	X	X	3422
Transport and Telecommunication Institute, Latvia – **TSI** (1999)[4]	1001+	X	X	X	5669
Kaunas University of Technology, Lithuania – **KTU** (1922)	801–1000	1201–1500	586	801–850	1301
Mykolas Romeris University, Lithuania – **MRU** (1990)	1001+	X	637	1001–1200	2509
Vytautas Magnus University, Lithuania – **VDU** (1922)	1001+	1201–1500	771–780	801–850	1775
Lithuanian University of Health Sciences, Lithuania – **LSMU** (2010)[5]	801–1000	801–1000	X	X	2003
Vilnius University, Lithuania – **VU** (1579)[6]	X	801–1000	474	473	709
Vilnius Gediminas Technical University, Lithuania – **VilniusTech** (1956)	X	1201–1500	1051–1100	801–850	1426
Klaipeda University – **KU** (1991)	X	X	X	X	2563
University of Tartu, Estonia – **UT** (1632)[7]	X	301–500	563	358	433
Tallinn University of Technology, Estonia – **TalTech** (1918)	X	601–800	1201+	651–660	1061
Tallinn University, Estonia – **TLU** (2005)[8]	X	1001–1200	X	1001–1200	1719

Source: THE (2024, 2023), QS (2024 a, 2024 b), EduRank (2024)

[1] established as Riga Polytechnic; since 1990 Riga Technical University

[2] established as Rīga Medical Institute; since 1998 Riga Stradiņš University

[3] established as Jelgava Academy of Agriculture; since 2008 Latvia University of Life Sciences and Technologies

[4] based on: Riga Civil Aviation Engineers Institute (1960) & Riga Aviation University (1992)

[5] based on: Lithuanian Veterinary Academy (1936) & Kaunas University of Medicine (1950)

[6] established as Jesuit Academy and University of Vilnius; since 1918 Vilnius University

[7] established as Academia Dorpatensis; since 1919 University of Tartu

[8] based on: Tallinn Pedagogical University (1919), Institute of History (1946), Academic Library of Estonia (1946), Estonian Institute of Humanities (1988), Baltic Film and Media School (1992)

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 2 – University SDG scaled scores (THE) and individual commitment to SDGs

HEI	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8
LU	V[9]	V	70.5 V	58.3 V	80.1 V	V	49.3 V	89.5 V
RTU			35.7 V	V		V	65.5 V	80.2
RSU	V	V	88.4 V	44.8 V	79.6 V	V	59.1 V	70.7 V
LBTU			29.8	31.6				
TSI[10]				~19	~39			~42
KTU	V	V	28.7 V	33.4 V	32.5 V		49.4 V	66.3 V
MRU	~44	~27	~17	~40	~59	~44	~25	~42
VDU				~40	~59			
LSMU			76.7	29.1	57.2			45.5
KU[11]	~44		~50	~40				~19
Estonia	not participating in 2023; 2024 results to be published in June 2024 (after submission of this paper)							

HEI	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
LU	79.9 V	V	71.1 V	V	39.8 V	V	V	77.0 V	81.5 V
RTU	87.0 V		64.0 V	67.6 V	65.5			64.0	63.3 V
RSU	V		54.0 V	V	V	V	V	64.5 V	68.9 V
LBTU			44.3				41.2	69.6	55.7
TSI								~15	~23
KTU	50.5 V	V	45.6 V	V	V	V	V	38.1 V	52.9 V
MRU	~26	~55	~30	~54	~34	~15	~54	~61	~23
VDU		~55							~49
LSMU									44.4
KU	~26							~37	

Source: THE (2023), SDG LU, SDG RTU, SDG KTU, SDG RSU

VU aims to create an interdisciplinary research and study environment focused on implementation of the SDGs – health and well-being, high quality education and climate change prevention (SP VU). For Lithuanian universities **VDU, LSMU, VilniusTech** the author could not find information linked to university's own SDGs.

[9] V - HEI has set own SDG

[10] for 1001+ ranked universities THE scaled values are not calculated; therefore, averaged scores adduced

[11] Klaipeda University – scored for individual SDGs, not included in the overall ranking

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.3 Education for sustainable development (ESD) at Baltic universities – screening results

ESD is a lifelong learning process and an integral part of quality education in making decisions and taking actions towards care for the planet. Some challenging undertakings of introducing ESD in Baltic countries are discussed by Henno (2015), Bērziņa (2019) and Dagilienė (2016).

For students who live according to the concept of sustainability, before entering a university, it is important to find out which ones perform according to sustainability principles, both in education and campus-life. As of today, all surveyed universities have stated – they promote education for sustainable development. It does not necessarily mean that not listed below universities are not engaged in ESD, but it is not obvious by open-access screening of their study programmes and/or courses.

According to the SDR (2023) **Estonia** is among 'top-10' in the overall ranking and above the EU average. For SDG4 the goal is achieved. **UT** offers a selection of courses related to the sustainable development goals and traineeship opportunities to help students enhance their future skills to solve complex problems[12]. **TalTech** offers an inter- and trans-disciplinary programme on Technology Governance and Sustainability where all key components of a sustainable socio-economic future are linked[13]. According to the notice of **TLU** Vice-Rector for Sustainable Development, sustainability is a component in every curriculum[14].

Latvia ranks in the 'top-20', and the SDG4 score is moderately improving with some challenges still to be met (SDR 2023). By September 2024 the restructuring of universities will be completed. All **LU** faculties will realise programmes/courses containing a sustainability component[15]; LU is a member of European School of Sustainability Science and Research (ESSSR) where teaching and research within the remit of sustainability science is further developed. All merged **RTU** faculties teach sustainability issues[16], particularly intensively – sustainable energy education and environmental technologies; RTU has joined to the Sustainable Development Solutions Network (SDSN). **RSU** primarily trains health-care specialists, but Faculty of Social Studies realises a study programme on International Business and Sustainable Economy[17]. **LBTU** provides knowledge and skills necessary for sustainable development of the society and has included sustainability issues in the study programmes of all faculties[18]; LBTU has elaborated a set of promotional materials 'Climate-

[12] https://ut.ee/en/sustainability-topics-in-university-of-tartu-courses (18.04.2024)

[13] https://taltech.ee/en/nurkse/programmes (18.04.2024)

[14] https://www.tlu.ee/en/mediahub/blogs/sustainability-component-every-curriculum (18.04.2024)

[15] https://www.lu.lv/en/studies/study-process/courses/courses (18.04.2024)

[16] https://stud.rtu.lv/rtu/vaaApp/sprpub (18.04.2024)

[17] https://www.rsu.lv/en/study-programme/international-business-and-sustainable-economy (18.04.2024)

[18] https://www.lbtu.lv/en/studies (18.04.2024)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

friendly agricultural practice in Latvia'[19]. Although participating in THE Impact rankings, **TSI** does not refer to sustainability in the description of the study programmes/courses.

According to the SDR (2023) for **Lithuania** significant challenges remain in achieving the SDG4 goal. Among different **KTU** programmes there are courses with a sustainability component[20]; the Institute of Environmental Engineering trains leaders in sustainable development. **MRU** is the leading university in social sciences in Lithuania promoting sustainability and social innovations while contributing to the decision-making process[21]; MRU takes part in the International Association of University Cluster Higher Education for Sustainable Development (HESD). Most of the **VDU** study programmes include courses on sustainability[22]; VDU implements pan-university project 'Go Green', which seeks to bring people together and encourage them to take care of the environment. **LSMU** pays considerable attention to sustainability issues in the curricula, especially in the field of veterinary medicine and food science[23]. **VU** has several programmes on sustainable development/finance management and a course devoted to SDGs[24]. **VilniusTech** is upgrading curricula of BSc/specialists, MSc, and PhD programmes with new modules on energetically and ecologically sustainable, affordable and healthy built environment[25]. **KU** programmes include courses on sustainability paying attention to renewable energy sources, renewable energetics, and energy efficiency[26]; KU is a part of pan-university project European University for Smart Urban Coastal Sustainability (EU-CONEXUS).

3. Discussion and conclusions

Baltic countries' achievements are often compared to the Nordic countries. According to the SDR (2023) the overall leaders for several years in a row scoring above 85 are Finland, Sweden, and Denmark. Since this study is dealing with universities, the main interest is SDG4: it is achieved for Finland and Estonia. For other Nordic countries, Latvia, and Lithuania the score is moderately improving, but some challenges still remain.

After the universities' policy documents, sustainability is an important strategic area and is integrated into studies, research, and campus-life at all surveyed Baltic universities. Open-access screening of the study programmes/courses on the university websites is not so

[19] https://www.lbtu.lv/en/climate-friendly-agriculture (18.04.2024)

[20] https://en.ktu.edu (18.04.2024)

[21] https://www.mruni.eu/en/prospective-students (18.04.2024)

[22] https://www.vdu.lt/en/vdu-studies (18.04.2024)

[23] https://lsmu.lt/en/for-students/study-programmes (18.04.2024)

[24] https://www.vu.lt/en/studies (18.04.2024)

[25] https://vilniustech.lt/tvarumo-centras/studijuok-tvaruma/363685 (18.04.2024)

[26] https://www.ku.lt/lt/studijos (18.04.2024)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

optimistic: only a part of them clearly indicate linkage to the sustainability issues and it is not easy to find a study programme just by the description. It could be beneficial if universities distinctly point out relations to sustainability in the description of the curricula instead of including general statement 'sustainability is a component in every curriculum'.

It should be noted that each country organises catalogue of study courses differently and a unified overview is burdened. Besides, references not found (both English and national language) does not mean the sustainability in the curriculum does not exist. Therefore, the study in all Baltic countries on a university's SDGs and sustainability issues in the university programmes would be more comprehensive if it is carried out in cooperation by locals in each country.

Acknowledgements and Conflicts of interest

No funding has been received for the development of the research. The author declares that she has no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

2030 Agenda. Transforming Our World: The 2030 Agenda for Sustainable Development (2015). *United Nations*, 40 pages

Bērziņa D. (2019). Learning by doing. Case study: Education for sustainable development at the University of Latvia. *Periodicals of Engineering and Natural Sciences*. 7 (1), 156-164. DOI: http://pen.ius.edu.ba/index.php/pen/article/view/356/249

Dagilienė L., Mykolaitienė V. (2016). Sustainability reporting in the higher education sector – Case study of Lithuania. *Zeitschrift Für Öffentliche Und Gemeinwirtschaftliche Unternehmen: ZögU*. 39(1/2), 163–174. DOI: http://www.jstor.org/stable/26429394

EduRank (2024). Retrieved April 18, 2024, from https://edurank.org

Filho W.L., et all (2023). SDGs in the European Region (edited book). *Springer Nature*. https://doi.org/10.1007/978-3-030-91261-1

Henno I. (2015). Ten years of Education for Sustainable Development in Estonia. *Ministry of Education and Research*. 10 pages

Kursīte J. (2020). Nokļūšana Tērbatā 17.–20.gadsimtā. In *Eduards Veidenbaums. Dzīve un daiļrade*. LU Apgāds, 107-108. https://doi.org/10.22364/edvei.07 (in Latvian)

PT KU (2020). Klaipėdos universiteto Plėtros strategija 2021–2030. *Klaipėdos universitetas*. 19 pages (in Lithuanian)

2024, Editorial Universitat Politècnica de València BY-NC-SA

QS (2024 a). QS World University Rankings 2024: Top global universities. Retrieved April 18, 2024, from https://www.topuniversities.com/world-university-rankings

QS (2024 b). QS Sustainability Rankings 2024. Retrieved April 18, 2024, from https://www.topuniversities.com/sustainability-rankings

SDG KTU (2022). Global sustainable development goals – KTU sustainability. *Kaunas University of Technology*. Retrieved April 18, 2024, from https://en.ktu.edu/university/sustainability/#1697610539330-55cb96a9-f29e

SDG LU (2022). Ilgtspējīgas attīstības mērķi. *Latvijas Universitāte.* Retrieved April 18, 2024, from https://www.lu.lv/par-mums/ilgtspejigas-attistibas-merki (in Latvian)

SDG RTU (2022). RTU Goals. *Riga Technical University*. Retrieved April 18, 2024, from https://www.rtu.lv/en/university/strategy/sustainable-development/rtu-goals

SDG RSU (2022). Sustainable Development Goals. *Rīga Stradiņš University*. Retrieved April 18, 2024, from https://www.rsu.lv/en/sustainable-development-goals

SDR (2023). Sustainable Development Report 2023. Implementing SDG Stimulus. *Dublin University Press*. 533 pages http://doi.org/10.25546/102924

SP VU (2020). Vilnius University Strategic Plan for 2021–2025. *Vilniaus universitetas*. 8 pages

SP UT (2020). University of Tartu Strategic Plan 2021-2025. *Adopted by the Council of the University of Tartu 20 April 2020*. 16 pages.

SSA MRU (2021). Mykolas Romeris University 2021-2023 Strategy for Sustainable Activities. *Mykolo Romerio universitetas*. 7 pages.

THE (2023). Times Higher Education Impact Rankings 2023 in partnership with ELSEVIER. *Times Higher Education*. 123 pages.

THE (2024). THE World University Rankings 2024, 20th Edition. *Times Higher Education in partnership with ELSEVIER*. 134 pages

VNR EE (2020). Review of the Implementation of the UN 2030 Agenda in Estonia. *Republic of Estonia Government Office*. 105 pages.

VNR LT (2023). Lithuania – Voluntary National Review on the Implementation of the 2030 Agenda for Sustainable Development. *Ministry of Environment Republic of Lithuania*. 104 p

VNR LV (2022). Latvia – Implementation of the Sustainable Development Goals – 2022. *Cross-Sectoral Coordination Centre*. 175 pages.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Exploring a quantification method of the Whole School Approach with regard to climate action

Lena Tholen[a], Frank Labunski[a], Oliver Wagner[a], Maike Venjakob[a], Sebastian Albert-Seifried[b]

[a]Wuppertal Institute for Climate, Environment and Energy, Germany
[b]Ö-quadrat, Germany

Abstract

The Whole School Approach (WSA) is a concept aimed at holistically shaping educational institutions in the context of education for sustainable development (ESD), encompassing all aspects of the school environment. The focus is not only on the curriculum and teaching methods but also on creating a conducive learning environment, involving all school activities and facilities. A central element is the inclusion of the entire school community, including teachers, students, parents, custodians, canteen staff, and external partners. The concept has been established for many years and serves as a guiding principle in a number of schools. However, there is a lack of a method to quantify the success of implementing the WSA. This paper provides a basis for discussion to operationalise the WSA. For this purpose, a new approach was developed that includes the involvement of different actors and the implementation of specific climate protection measures (in teaching, energy saving measures in schools, promotion of renewable energies). The index score we developed is based on the allocation of evaluation points, which are useful for operationalising the WSA. Points are assigned in a clearly structured approach to make the results comparable. This new approach was tested with 12 German schools participating in the Schools4Future project (www.schools4future.de), confirming that the more diverse groups of stakeholders are involved, the more effective climate protection measures are implemented. However, it was also observed that key actors (especially students, teachers) can be largely responsible for a successful implementation of climate action measures.

Keywords: whole school approach; CO_2 balance; assessment scheme; stakeholder analysis.

How to cite: Tholen L.; Labunski, F.; Wagner, O.; Venjakob, M. and Albert-Seifried, S. (2024) Exploring a quantification method of the Whole School Approach with regard to climate action. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 510-517. https://doi.org/10.4995/SEED2024.2024.xxxxx

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the pursuit of climate goals, the implementation of climate protection measures across all sectors, including municipalities, is of paramount importance. Within this context, public buildings such as schools assume a pivotal role in advancing these goals, given their considerable potential for energy savings. Despite the ambitious climate goals of some municipalities, the building condition oy many German schools in particular with regards to energy efficiency is insufficient. This also applies if there is still substantial unused potential in the areas of heating systems, building insulation, lighting and the use of renewable energy. The challenge frequently resides in the lack of financial resources to address the high backlog in investments. This is particularly dramatic, because schools are places where the next generation spends many hours daily, preparing for their future. Brand und Salzgeber (2022) emphasise the relevance of functional school buildings as a crucial prerequisite for an efficient education system.

The goal of the Schools4Future project, funded by the Federal Ministry for Economic Affairs and Climate Protection in Germany until mid-2023, was to accompany schools in their journey towards climate neutrality. Among other things, schools were supported in assessing their CO_2 emissions. The aim was to identify the potentials for climate protection, to develop measures and, by doing this, to reduce greenhouse gas emissions. The project adopted a WSA, emphasising a comprehensive approach within ESD. Students and other actors were taught methods for creating future perspectives and demonstrating skills for action. Additionally, schools were seen as places where active participation can contribute to enabling sustainable development within the school and beyond (Bundesministerium für Bildung und Forschung, 2017).

The first step in the Schools4Future project was the compilation of an energy and CO_2 balance, covering building energy, mobility, nutrition, and procurement. Utilising an Excel-based CO_2 tool, students and teachers can determine their school's carbon footprint with minimal background knowledge and independently without using the services of an engineering office. The CO_2 balance was the basis for the school communities to develop climate protection measures and implement concrete actions: For example, one school adjusted its menu in collaboration with the canteen staff, reducing meat offerings to only twice a week. Another school experimented with flexible portion sizes to minimise food waste. To reduce energy consumption, one school improved window tightness by replacing sealing strips. In terms of mobility, several schools dismissed air travel plans and switched to more climate-friendly modes of transportation for class trips. In addition to implementation projects, awareness-raising measures were also an issue in many schools. Teachers developed ideas on how to integrate climate protection more strongly into the curriculum. Furthermore, three schools organised climate action days with information material and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

presentations on climate protection topics. Beyond the implementation of measures in schools, Schools4Future also aimed to demonstrate how students can actively engage in political processes. Knowledge about CO_2 emissions and existing CO_2 saving potentials served as the basis for making contact with policymakers, presenting possible actions, and making demands. Students were initially informed about relevant actors for climate protection in schools, ranging from mayors to energy providers and local transport companies. Subsequently, they were provided with options to engage with these actors, either by inviting them to school events, collecting signatures, or formulating petitions.

2. The Whole School Approach

The concept of the WSA encompasses a strategy that takes a comprehensive view of all aspects of school life, including the pedagogical framework, curriculum, learning materials, facility management and various school activities. The objective is to ensure that sustainability is not only a topic in the classroom or promoted through selective initiatives but is instead embedded in the entire school's structure. Schools can be particularly impactful when they operate holistically as entire institutions, involving not only their pedagogic components but also engaging non-school partners. This entails ensuring that actions align with the stated values. The primary goal of this approach is to facilitate self-efficacy experiences within the school community. Therefore, it necessitates the active participation of school management, teachers, students, parents, custodians, representatives of local politicians and administration, as well as civil society partners like school support associations and non-governmental organisations (UNESCO, 2016).

The significance of the WSA resides in the acknowledgment that a school that addresses climate change in the classroom but neglects endeavours towards energy and resources savings lacks credibility as an institution. A holistic perspective entails a high valuation of participation, as an essential element of democracy and guiding principle for students. Nowadays, school activities have gained the attention of school stakeholders and researchers due to their potential towards organisational change in different areas. However, these approaches often examine the effectiveness of individual components in isolation, such as the heating system or walking to school. Hence, there is an urgent need for the development and implementation of measures capable of effecting comprehensive change (Helme et al., 2022).

Nevertheless, this WSA is not new and has been further developed and researched worldwide for many years. Examples for successful implementations of the WSA into the curriculum are Australia, Japan and Finland (Sasaki 2023; Larri & Colliver 2020, Mykrä 2023). Furthermore, researchers have shown that this approach has a positive impact on school climate, learning outcomes and student well-being (Mathie & Wals 2022; Holst 2022). Implementation varies

2024, Editorial Universitat Politècnica de València BY-NC-SA

by context, but the core idea of engaging the whole school in promoting values, behaviors and learning environments remains.

So far, what is lacking is the ability to quantify and evaluate the WSA. This article aims to provide an impulse on the extent to which schools are making good progress in implementing the WSA and which elements should be considered in this regard.

2.1 Stakeholders Analysis

In line with the WSA, it is crucial to involve as many stakeholders as possible in climate protection measures, each contributing to the overall success. The CO_2 balance relies on the cooperation of the school authority and the secretariat, who must provide essential data, such as information regarding school trips. The involvement of local administration is also required for sharing data on energy consumption (electricity, heating) and, if applicable, information about renewable energies (like a photovoltaic system). Additionally, the CO_2 balance is particularly relevant for the school community to generate ideas and implement concrete measures. Therefore, it is important that a group of students and teachers, ideally supported by additional stakeholders like parents or partner schools, consistently advocate for climate protection within the school and collaborate with the other stakeholder. The custodian, for instance, has the best knowledge on the building technology, changes to the menu depend on the agreement of canteen staff.

Although numerous possibilities exist for schools to reduce greenhouse gas emissions, especially with regard to lower-cost measures, there are limitations concerning higher-investment initiatives. Consequently, it is essential for schools to extend their efforts beyond their school environment, contacting other actors such as representatives of local politicians and administration, who can facilitate the replacement of outdated heating systems or inefficient lighting. Partnerships within the local community and with other schools are often promising avenues for exchanging experiences. To gain an overview of the relevant stakeholders within the school and understand their potential influence, conducting a stakeholder analysis can be a helpful option.

2.2 Quantification of the Whole School Approach

The aim of our approach is to improve the quantitative measurement of the WSA and to confirm or reject that the implementation of the WSA has a positive influence on successful self-efficacy experiences of students in the area of climate protection efforts. Therefore the theoretical terms "Whole School Approach" and "Successful Self-Efficacy" were converted into empirically measurable characteristics (see Table 1). In a first step, an analysis was conducted on how key stakeholders were involved in school activities related to climate protection. Our focus was on the following stakeholders: students, teachers, parents,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

custodians, social workers, canteen staff, school principal and school authorities. Nevertheless, the assessment matrix has the potential to be adapted in accordance with the stakeholder analysis. The list of stakeholders is also visible in Table 1, indicating the tasks or roles of each stakeholder. As mentioned earlier, the assessment matrix is closely aligned with the Schools4Future project and should be understood as a basis for discussion to quantify the WSA. This list of stakeholders should therefore be adjusted if necessary.

The nominal indicators were 0 (no/does not apply) and 1 (yes/does apply) to all stakeholders and the total score was calculated by summing up the individual indicators. Subsequently, the final WSA score was determined by adding together the scores of all stakeholders. Each stakeholder could achieve a maximum WSA score of 5 or 6 points, resulting in a total possible score of 47 points. A higher score indicates a more robust implementation of the WSA at the school, thereby serving as an index value for the WSA implementation.

Table 1 – Matrix used for the evaluation of the Whole School Approach score

Matrix used for evaluation of whole school approach score	were informed about the project	involved in the CO_2 balance	involved in further climate protection	participated in presentation of results	participated in climate action day or similar	Exchange with other schools or training	Supported the project	participated in project meetings	provided resources	provided teaching time for all classes	publication of results on webpage	Maximum possible points
Students	1/0	1/0	1/0	1/0	1/0	1/0						6
Teaschers	1/0	1/0	1/0	1/0	1/0	1/0						6
Custodians	1/0	1/0	1/0	1/0	1/0	1/0						6
Cantene workers	1/0	1/0	1/0	1/0	1/0	1/0						6
Social worker	1/0	1/0	1/0	1/0	1/0	1/0						6
Parents	1/0	1/0	1/0	1/0	1/0	1/0						6
school authority	1/0	1/0	1/0	1/0			1/0					5
school principal						1/0	1/0	1/0	1/0	1/0	1/0	6
Maximum possible WSA score												**47**

Source: own elaboration

The self-efficacy score was determined through a simple questionnaire. In contrast to the matrix used to calculate the WSA score, no differentiation was made between different stakeholders; instead, the successful implementation of specific climate protection measures was assessed. The reason is the fact that many actors are often involved in a specific measure. The questions were selected on the basis of observations from the Schools4Future project. That is why, in this case, the questionnaire was completed by researchers who accompanied the school activitites. However, in principle, the questionnaire can also be easily assessed by school actors. For each specific measure (e.g., completion of the CO_2 balance), one point could be awarded. A school can achieve a maximum of 8 points with this questionnaire (see Table 2).

 BY-NC-SA

Table 2 – Questionnaire used for evaluation of the self-efficacy score

Questionnaire used for evaluation of the self-efficacy score	
CO_2-balance was completed	1/0
CO_2-balance was persented to public	1/0
Climate protection concept created/measures developed	1/0
Political engagement (e.g. Dialogue with school authorities/politicans/petitions)	1/0
Climate protection measures implemented	1/0
Climate protection day held	1/0
Futher commitment outside the project, e.g. participation in competitions	1/0
Media coverage (newspaper, radio, televeision)	1/0
Maximum posible result for self-efficacy score	**8**

Source: own elaboration

The use of a quantification method with only two values (yes/no) was chosen to provide simplicity and clarity in decision-making processes. It enables an straightforward assessment without the ambiguity that could arise, for example, when using a scale (1-5). Due to the new development of the method, the complexity and level of detail should be low in order to start the discussion easily. For a further development of the approach, however, a scale also offers opportunities to assess the activities more precisely and to better differentiate between different characteristics.

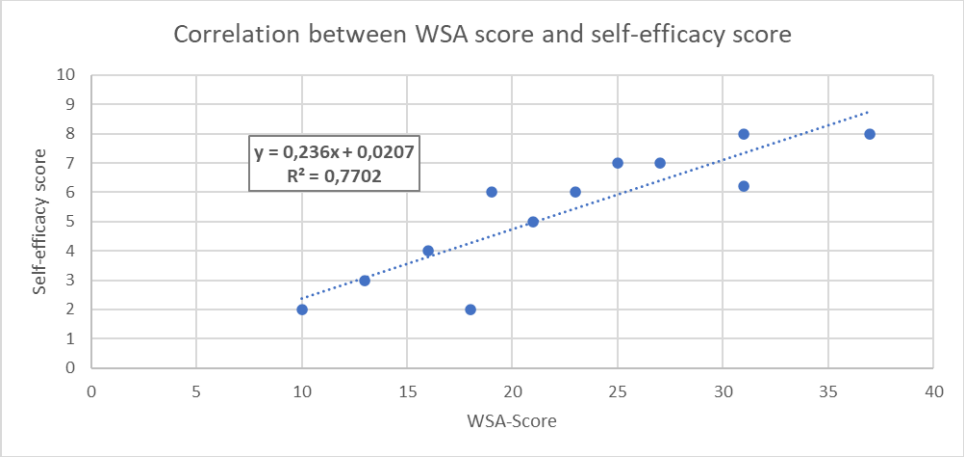
3. Results

We have developed a new method to quantify the WSA. In doing so, we investigated whether the WSA and the involvement of various stakeholders are useful to experience self-efficacy of students and other participants. This involved examining both climate protection activities through individual activities and political engagement. Given the innovative nature of the approach and the sample size of 12 schools, this presentation is limited to initial findings. Nevertheless, these results can serve as a discussion basis for future analyses of the WSA. The findings imply that the hypothesis regarding the effectiveness of the WSA in fostering self-efficacy in schools can be confirmed. Further research is needed to validate these early findings and acquire a more thorough understanding of the impact of the WSA on students' self-efficacy experiences.

The correlation between the WSA score and the self-efficacy score of the Schools4Future schools are shown in Figure 1. The strong positive correlation between the two parameters is directly visible. The Pearson correlation coefficient was obtained as r=0.88, with a p-value of 0.0002. This demonstrates a significant correlation between the two parameters, suggesting that the implementation of a WSA positively influences the success of self-efficacy in schools.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Correlation between WSA score and self-efficacy score of the Schools4Future schools



Source: own elaboration

4. Conclusion and Discussion

As of today, there is no established instrument available to quantify self-efficacy and Whole School Approach within the context of ESD. However, the proven statistical correlation between the WSA and self-efficacy score shows the effectiveness of this approach. Nevertheless, the small sample size of 12 schools requires significant further research to validate the self-efficacy of students and other participants. With our proposal, we aim to establish a foundation for further consideration and analysis. Research in the context of ESD stands to gain from a better operationalisation of these often-discussed concepts, which would be a first step towards enabling comparisons. Our exploratory analyses can help to create a basis for a further, more in-depth valuation analysis.

Acknowledgements

The Schools4Future project was supported by the German Federal Ministry for Economic Affairs and Climate Action (project duration: May 2020 – June 2023). The responsibility for the contents lies solely with the authors.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

 BY-NC-SA

References

Brand, S., & Salzgeber, J. (2022). Kosten steigen schneller als die Investition: Bedarf für Schulen weiter hoch. (Nr. 401, 13. September 2022) [KfW Reseach]. KfW

Bundesministerium für Bildung und Forschung. (2017). Nationaler Aktionsplan Bildung für nachhaltige Entwicklung. Der deutsche Beitrag zum UNESCO-Weltaktionsprogramm. https://www.bne-portal.de/bne/shareddocs/downloads/files/nationaler_aktionsplan_bildung-er_nachhaltige_entwicklung_neu.pdf?__blob=publicationFile&v=2

Helme, Z. E., Morris, J. L., Nichols, J., Chalkley, A. E., Bingham, D. D., McLoughlin, G. M., Bartholomew, J. B., & Daly-Smith, A. (2022). Assessing the Impacts of Creating Active Schools on Organisational Culture for Physical Activity. International Journal of Environmental Research and Public Health, 19(24), 16950. https://doi.org/10.3390/ijerph192416950

Holst, J. (2022): Towards coherence on sustainability in education: a systematic review of Whole Institution Approaches. . In: Sustainability Science (2023): 18:1015-1030

Kuschnereit, A., & Vockerodt, Y. (2013). Öffentlichkeitsarbeit. Konzepte und Ideen für Schulen. https://www.hamburg.de/contentblob/1903036/18f6586b136d7d65d49e56378e89bca6/data/handout.pdf

Larri, L., Colliver, A. (2020). Moving Green to Mainstream: Schools as Models of Sustainability for Their Communities – the Austalian Sustainable Schools Initiative (AuSSI). In: Gough, A., Lee, J. C. K., & Tsang, E. P. K. (2020). Green schools globally. Cham, Switzerland: Springer International Publishing.

Mathie, R.G., Wals, E.E.J. (2022): Whole School Approaches to Sustainability: Exemplary Practices from around the world. Wageningen: Education & Learning Sciences/Wageningen University. https://doi.org/10.18174/572267.

Mykrä, N. (2023). Ecological Sustainability and Steering of Finnish Comprehensive Schools. In: Thrupp, M., Seppänen, P., Kauko, J., Kosunen, S. (eds) Finland's Famous Education System. Springer, Singapore. https://doi.org/10.1007/978-981-19-8241-5_6

Sasaki, O., Yonehara, A., Kitamura, Y. (2023). The influence of the whole school approach on implementing education for sustainable development in Japan. Prospects (2023). https://doi.org/10.1007/s11125-023-09667-4

BY-NC-SA 2024, Editorial Universitat Politècnica de València

A Study on SDG Awareness in Computer Science Curricula

Vicente R. Tomás, Sandra Catalán, Mª Isabel Castillo and Germán León

Department of Computer Science and Engineering. University Jaume I. Spain

Abstract

Sustainable computing is not a new concept and has re-emerged in the context of the Sustainable Development Goals (SDGs). As a high level of the educational process, universities can play a key role in achieving the goals and targets of the SDGs.

This paper describes the work developed in two innovative educational projects, to know the level of students' awareness and understanding of sustainable practices and the SDGs. The study focused on four subjects in the seventh semester of the computer science degree. A survey has been done, in two consecutive academic years, to analyse the degree of awareness of students on SGDs.

Results are positive and the actions developed in the frame of the innovative projects have improved the students' knowledge about SDGs in the second year. Furthermore, we consider that the work not only has provoked an enhancement in SDG knowledge but also an awareness among students about their possibilities regarding their potential contributions and opportunities to sustainability.

Keywords: Sustainability; SDGs; Computer Science.

How to cite: Tomás, V.R.; Catalán, S.; Castillo, M.I. and León, G. (2024) A Study on SDG Awareness in Computer Science Curricula. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 518-526. https://doi.org/10.4995/SEED2024.2024.xxxxx

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Since the Bologna Process, the development of competencies in universities has been a fundamental objective in the design of curricula. In this process, a huge change has been produced, pushing learning outcomes and competencies, both soft and specific, as the core element of the curricula.

This approach supports the shift from the traditional lecture-style teaching to active and experimental learning, where students engage in practical activities, projects, internships, and other experiences that allow them to apply and develop these competencies.

On the other hand, in 2015, United Nations Member (2024) States adopted the 2030 Agenda for Sustainable Development. This Agenda includes an action plan outlining 17 Sustainable Development Goals (SDGs). One key element to achieve these SDGs is the development of strategies promoting education at all levels, especially in higher education.

Over the last two years, the interest and advancements in Computer Science and Artificial Intelligence (AI) have been remarkable. The emergence of AI applications, such as ChatGPT and others, has played a significant role in showcasing the potential and impact of AI on various aspects of our lives. Furthermore, despite not being a novel concept, in recent years, and in connection with the SDGs, the concept of Sustainable Computing has resurfaced.

Gomes (2011) refers to Sustainable Computing as interdisciplinary research aiming to develop computational models, methods, and tools to help manage the balance between environmental, economic, and social needs for sustainable development.

Tomás (2023) describes that universities are responsible organizations to spearhead the realization of SDGs for several compelling reasons: 1) serving as hubs of knowledge, they bear the responsibility of shaping the next cohorts of leaders, 2) equipped with intellectual prowess, research acumen, and innovative capabilities, they are well-positioned to drive advancements, and 3) their far-reaching influence on local communities underscores their pivotal role in substantially impacting the attainment of SDGs.

So, fostering the development of Sustainable Computing at universities presents an intriguing opportunity for a win-win approach: simultaneously advancing computer science education while contributing to sustainable practices.

This paper presents the work developed at University Jaume I to enhance students' awareness and understanding of sustainable practices and SDGs. The paper is structured as follows: next section presents the context and the background of the study. Then, in Section 3 the characteristics of the Computer Science degree in which the study has been developed are described. In Section 4, the results of the survey and the discussion are presented. Finally, the conclusions of the work and future steps are discussed.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Context and background

The integration of eco-friendly practices into the design, deployment, and use of computing technologies is essential for mitigating the environmental impact of the rapidly advancing digital landscape and the core backbone of Sustainable Computing.

Gomes et colleagues (2019) describe that sustainability problems offer not only challenges but also opportunities for the advance of computing and information science. They link three distinct areas: 1) balancing environmental and socio-economic needs; 2) biodiversity and conservation; and 3) renewable and sustainable energy and materials with three computational areas: 1) optimization, dynamic models, and simulation; 2) data and machine learning; and 3) multi-agent systems, crowdsourcing, and citizen science. Furthermore, the importance of the SDGs to sustainable computing will be highlighted.

Muñoz-Rodríguez (2020) and García-Hernández (2022) identified the key aspects of sustainability education. They recommend the development of activities to foster students' attitudes of action and commitment. Furthermore, skills such as fostering critical thinking, addressing dilemmas, and encouraging the exploration of solutions to problems must also be included in the lectures.

Specific subjects have been created and are being taught in different universities. In 2016, at Stanford University, a subject called "Topics in Computational Sustainability - CS325" was part of the curricula, focusing on the advancement of computational models, methodologies, and tools to assist policymakers in formulating more impactful strategies for sustainable development. At Cornell university, (2019) there is a subject "Excursions in Computational Sustainability - CS 2770". In CompSustNet (2023), more examples of courses can be found on the website of Computational Sustainability Network.

At University Jaume I, one of the relevant technical degrees is Computer Science. It spans four academic years, with each year accounting for 60 ECTS credits. The academic year comprises 40 teaching weeks, organized into two semesters, each lasting 20 weeks with similar workload. The degree encompasses four distinct curricular specializations: Information Systems (IS), Software Engineering (SE), Information Technologies (IT), and Computer Engineering (CE). During the eighth semester, students are required to undertake a final-year project, engaging in a 300-hour work placement within a company.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Analysing the level of knowledge of SDGs in a Computer Science Degree

In the past two years, an innovative educational project has been developed. One of the main project objectives, among others, was to foster SDGs in Computer Science. An anonymous survey was prepared to assess the level of knowledge of students on this topic. All students in the semester were invited to participate, as one subject from each specialization has been selected. Subjects are: EI1038 Database System Design (IS), EI1041 - Database Design and Implementation (SE), EI1052 - Database Management Systems (IT), and EI1060 - Digital Systems Design (CE). It is important to note that subjects EI1038 and EI1041 are taught together, so the survey results are integrated as if both were a single subject. Furthermore, this year a new subject, IR2160, was included in the study. This subject belongs to the bachelor's degree in Robotic Intelligence.

Tomás (2023) presents the results of the first-year project. Results were significant: in the academic year 2022/23 there was a big unawareness about the SDGs and only 29% knew about them. In addition, SDG goals 4, 5, 8, and 9 were identified by students as ones that can be addressed in the subjects.

Therefore, in the academic course 2023/24, a set of different activities was developed for each subject to improve the knowledge of the SDGs and to present different ways in which students can integrate the principles of the SDGs into their professional development to contribute effectively with the achievement of the SDGs.

The proposed activities were:

- All subjects are participating in two new innovative educational projects. So, goal 4 is being improved.
- In subjects EI1038-41 and EI1052 the teaching methodology is Team Project-based Learning (TPBL). Therefore, to improve goals 8 and 9, the purpose and content of the project has been oriented towards environmental and sustainable aspects, such as a system for measuring emissions.
- Subject EI1060 is participating in the innovative educational project "Encouraging Active Learning in Computer Architecture and Technology Courses". A specific ODS activity has been developed to raise awareness in students. The work consisted of finding and developing a small project related to digital systems and an SDG chosen by the teacher.

Although a specific session on the SDGs was initially considered, this idea was rejected because the university proposes various general actions to explore and understand the SDGs. Therefore, the actions carried out were related to the daily activities of the subjects but indirectly linked to the SDGs.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The survey is composed of four questions:

- Q1.- Do you know what the SDGs are?
- Q2.- Do you know the seventeen goals?
- Q3.- Of the 17 objectives, which one(s) do you think we can work on in the subject?
- Q4.- Do you know the TV show "Temptation Island"? (control question)

4. Results and discussion

In this section, the results of the survey are presented. Table 1 presents the figures of the students enrolled in the different subjects.

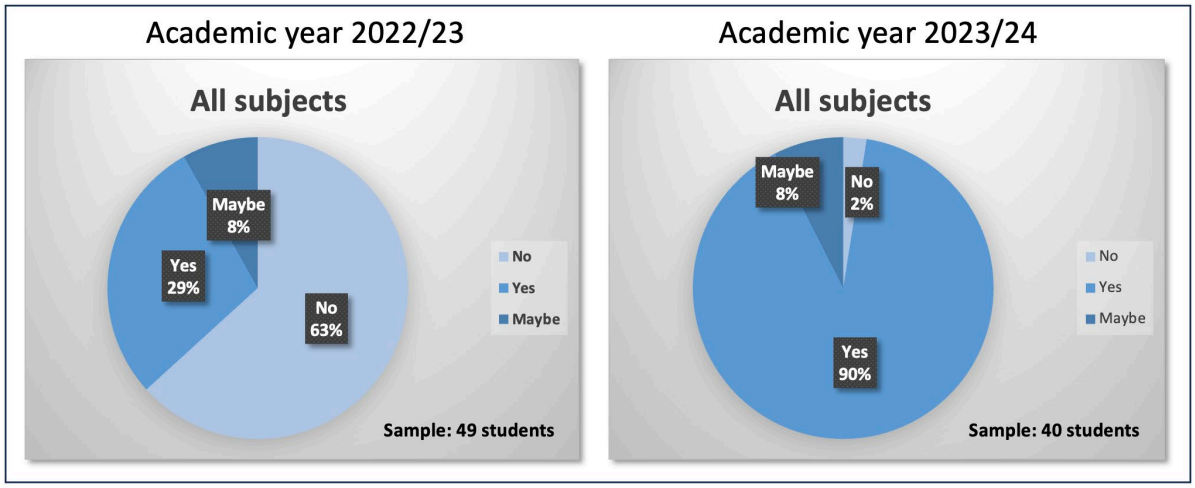
Table 1.- Number of students who have answered the survey. In the academic year 2022/23subject IR2160 does not have started the lectures.

Year	EI1038-41	EI1052	EI1060	ALL	IR2160
2022/23	28	9	12	49	--
2023/24	25	8	7	40	8

Source: Own elaboration

Figure 1 shows the level of knowledge about SDGs of all students (Question Q1), independently of the subject they were enrolled. The left graph shows the results of the previous year, academic year 2022/23, while the right graph shows the results of the current academic year.

Figure 1.- Survey results of Q1. Do you know what the SDGs are?



Source: Own elaboration

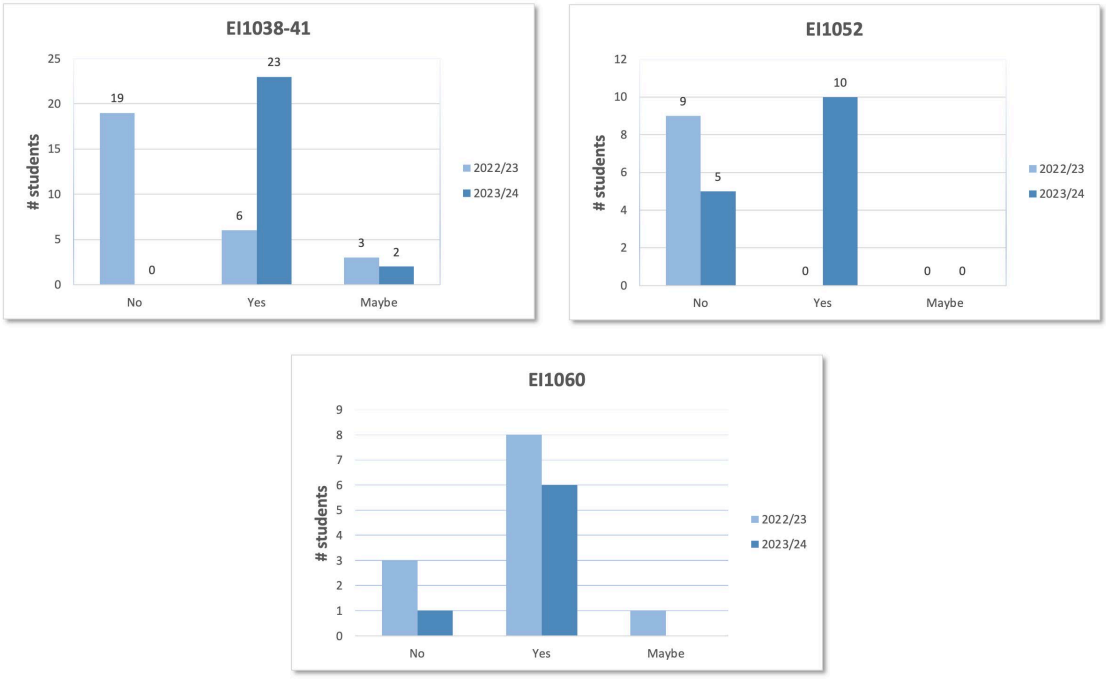
The results show a notable change in trend. While in the course 2022/23 only 29% know about SDGs, in 2023/24 this percentage increases to 90%. It is interesting to note that the result for students who are not sure is the same in both years. Analysing the results of subject IR2160,

2024, Editorial Universitat Politècnica de València BY-NC-SA

in academic course 2023/24, the results were that 57% of students are aware about SDG and 43% do not know anything about the agenda 2030 and SDG.

Next, Figure 2 shows the results of the same question, but now sorted by subject.

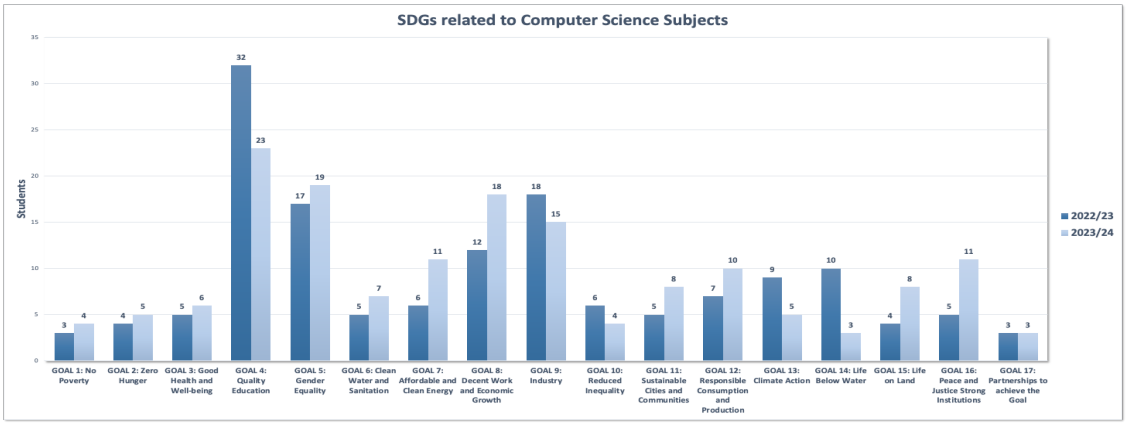
Figure 2.- Survey results of Q1. Do you know what the SDGs are? Sorted by subject.



Source: Own elaboration

Figure 3 presents the results of Question Q3. The purpose of this question is to identify the goals that can be worked on within the subjects.

Figure 3.- Students' point of view for two academic years. Relevant that can be worked on in the subjects.



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Although the subjects are quite different, not only in content but also in learning methodologies, and the students have different opinions, the results are similar, identifying the same four goals over the rest. These goals are:

- Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Goal 5. Achieve gender equality and empower all women and girls.
- Goal 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
- Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

All goals are directly related with university studies, and therefore, with our work. Goal 4 can be fostered in the Computer Science programme by improving the learning process in the different subjects. In this framework, teachers can participate in innovative learning projects to include new learning techniques (active learning, flipped classroom, PBL and others) but also to foster soft skills, that have been pointed out by the Accreditation Board for Engineering and Technology Association – ABET (2021).

Goal 5 can be promoted at the university in several ways. In the classroom, activities must ensure gender equality and create inclusive environments where all students have equal opportunities to participate and lead. These activities must be designed not only for university students but also for young people who will be future students to foster gender equality beyond the university.

Goals 8 and 9 can also be fostered as Goal 4. The importance of sustainable industrialization and innovation can be approached from different angles, making students aware of its importance throughout the learning process.

4. Conclusions

In this paper, a study about student awareness of SDG is presented. To determine the level of knowledge of the SDGs, an anonymous survey was designed for two consecutive academic years, 2022/23 and 2023/24. The surveyed subjects cover all four curricular specializations.

The results are highly positive, and the work done to raise the level of awareness of the SDGs could be considered adequate. This awareness has increased significantly, rising from 23% to 90%. Only in one subject, EI1060, the percentage was reduced, but only for few students. We have analysed the relevance of different SDGs for the students and identified which ones we can integrate into Computer Science subjects. So, four goals stand out among others in the span of two years: Goals 4, 5, 8 and 9.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

It is important to highlight the response rate among students who participated in the survey. While the number can be considered representative, s because all students in the four programs had the opportunity to participate, the percentage is still low compared to the total enrolment in the respective programs. So, for next year, more subjects, from different courses will be included in the survey.

Acknowledgements

This work has been developed by members of the innovative educational projects "Fostering active learning through computational sustainability projects in Advanced Database subjects." and "Building Knowledge Together: Promoting Collaborative Learning in the Classroom", both funded by University Jaume I for years 2024-26.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

ABET. Accreditation Board for Engineering and Technology (2021). Criteria for Accrediting Engineering Programs, 2017 – 2018. Online Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2017-2018/#GC3. Last access: 20 December 2021.

CompSustNet (2023) Courses of the Computational Sustainability Network https://www.compsust.net/education.php.

Cornell University (2019). Subject CS 2770 - Excursions in Computational Sustainability, https://classes.cornell.edu/browse/roster/SP19/class/CS/2770.

García-Hernández, Alién & García-Valcárcel, Ana & Martín, Sonia & Cabezas-González, Marcos. (2022). Sustainability in Digital Education: A Systematic Review of Innovative Proposals. Education Sciences. 13. 33. 10.3390/educsci13010033.

Gomes, C.P. (2011). Computational Sustainability. In: Gama, J., Bradley, E., Hollmén, J. (eds) Advances in Intelligent Data Analysis X. IDA 2011. Lecture Notes in Computer Science, vol 7014. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-24800-9_2

Gomes, Carla & Fern, Xiaoli & Fink, Daniel & Fisher, Doug & Flecker, Alexander & Freund, Daniel & Fuller, Angela & Gregoire, John & Hopcroft, John & Kelling, Steve & Kolter, Zico & Dietterich, Thomas & Powell, Warren & Sintov, Nicole & Selker, John & Selman, Bart & Sheldon, Daniel & Shmoys, David & Tambe, Milind & Fern, Alan. (2019). Computational sustainability: Computing for a better world and a sustainable future. Communications of the ACM. 62. 56-65. 10.1145/3339399.

Muñoz-Rodríguez JM, Sánchez-Carracedo F, Barrón-Ruiz Á, Serrate-González S (2020). Are We Training in Sustainability in Higher Education? Case Study: Education Degrees at the University of Salamanca. *Sustainability*. 2020; 12(11):4421. https://doi.org/10.3390/su12114421

BY-NC-SA 2024, Editorial Universitat Politècnica de València

OECD. Organization for Economic Cooperation and Development (2011) "Better skills, better jobs, better lives: A strategic approach to education and skills policies for the United Arab Emirates,", 2015. Online Available: http://www.oecd.org/countries/unitedarabemirates/A-Strategic-Approach-to-Education-and%20Skills-Policies-for-the-United-Arab- Emirates.pdf. Last access: 21 December 2021.

Tomás, V. R, León G, García L & Aramburu M.J (2023). The development of SDGs in Computer Science subjects.15th International Conference on Education and New Learning Technologies. Palma de Mallorca (España) 2023. ISSN: 2340-1117

United Nations (2024). Department of Economic and Social Affairs. Sustainable Development. United Nations. https://sdgs.un.org/2030agenda. Last access January 2024.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Integrating Service-Learning and Sustainability into the Engineering Curriculum: A Waste Management Case Study

María Linares Serrano[a], Inés Moreno García [a], M. Isabel Pariente Castilla [b]

Teaching innovation group in effective management of collaborative work in technological subjects
[a]Department of Chemical, Energy and Mechanical Technology, ESCET, Universidad Rey Juan Carlos, Spain
[b]Department of Chemical and Environmental Technology, ESCET, Universidad Rey Juan Carlos, Spain

Abstract

During the 2022-23 academic year, teaching staff from the Chemical Engineering area of the Higher School of Experimental Sciences of the Rey Juan Carlos University (URJC) developed the service-learning project "ReciclandoURJC". The project's primary objective was to provide students from various engineering disciplines with meaningful learning experiences in managing and treating household solid waste. Simultaneously, it offered them an opportunity to contribute a valuable service to the university community. This innovative methodology was integrated into the Final Degree Project across different engineering studies. By emphasizing solid waste management, the project not only encouraged more sustainable practices but also fostered a committed and environmentally conscious community. Furthermore, students developed essential civic and social skills, including interdisciplinary teamwork (across Energy, Environmental, and Industrial Engineering), leadership, effective communication, and a heightened awareness of their role in enhancing social and environmental well-being. Active student participation included conducting awareness-raising activities on waste minimization and proposing and evaluating waste treatment solutions for the campus. Overall, the "ReciclandoURJC" project successfully exemplifies the integration of Service-Learning within the technological academic field, allowing students to apply their acquired knowledge to benefit the community and contribute to the achievement of Sustainable Development Goals.

Keywords: Bachelor´s Degree Final Project; Active Learning; Engineering Degrees; Solid Wastes; Sustainable Development Goals.

How to cite: Linares Serrano, M.; Moreno García, I.; Pariente Castilla, M.I. (2024) Integrating Service-Learning and Sustainability into the Engineering Curriculum: A Waste Management Case Study. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 527-534.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Service-Learning (SL) is a pedagogical approach that bridges classroom learning with real-world community service. In the context of higher education, SL provides students with meaningful experiences while letting them contribute to societal needs, building students' civic engagement by allowing them to work in real-world contexts and addressing social needs. This methodology was described (Bringle and Hatcher, 1995) as a course-based, credit-bearing educational experience that allows students to:

- participate in an organized service activity that meets identified community needs

- Reflect on the service to help them gain a better understanding of what the service involves.

Therefore, this methodology can be implemented in degree studies in the technological field, connecting the participation of students in community service with the acquisition of knowledge, skills, and values in sustainability (Gomes, 2020). This facilitates meaningful and contextualized learning in a collaborative environment.

To develop a project of this type, it is necessary to identify a societal need that can be addressed through the set of activities to be carried out by students. One of the most pressing issues facing today's society is the increasing waste generation from various domestic, commercial, and industrial activities, particularly affecting large cities. Improper waste management can lead to severe environmental and public health problems, including the emission of greenhouse gases, the spread of infectious vectors, and soil and water resource degradation. To tackle this problem, public administrations are directing their environmental policies toward implementing a Circular Economy. The goal of a Circular Economy is to maintain the value of products, materials, and resources in the economy for as long as possible while minimizing waste generation. This requires a shift in the waste management model, emphasizing material reduction, reuse, and recycling instead of disposal. By doing so, we can achieve more efficient resource utilization and reduce the environmental impact associated with waste generation. In this context, the Government of Spain promulgated, in April 2022, the new law on Waste and Contaminated Soils for a Circular Economy (Law 7/2022 of April 8), which regulates the production and treatment of waste to minimize the negative impacts derived from its generation and management. Among other aspects, Law 7/2022 establishes a waste management hierarchy in which the most sustainable alternatives, such as prevention, reuse, and recycling of waste, are prioritized over energy recovery or landfilling. In addition, it establishes the specific objective of reducing the weight of waste by 13% by 2025 and 15% by 2030 compared to the amount of waste generated in 2010. Separation at source is a key factor for improving reuse and recycling rates of waste, materials, and/or by-products, since it increases the quality of the raw material to be treated, as well as the efficiency of the possible treatments and processes to be carried out. In this

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

sense, article 25 of the Waste Law 7/2022 obliges citizens, commercial entities, and public administrations to carry out separation at source and subsequent separate collection of the paper, metal, plastic, and glass waste fractions, as regulated by the previous legislative framework, in addition to biowaste of domestic origin, including the organic and plant fraction.

To achieve these objectives and move towards the implementation of a Circular Economy, work must be done on two fundamental pillars. The first of them is citizens' awareness and environmental education regarding waste management so that they can assume their responsibility in the transition towards a more sustainable, productive, economic, and social system. To do this, citizens must be informed of the changes established in the new legal framework, as well as the positive aspects that an improvement in waste management implies in their quality of life. Environmental education provides the knowledge and awareness necessary for the population to understand the importance of these practices and integrate them into their daily lives (Dale, 2005).

2. Methods

The SL project "ReciclandoURJC" was developed during the 2022/2023 academic year with the active participation of four students from the degrees of Environmental Engineering, Energy Engineering and Industrial Organization Engineering, and three teachers from the Chemical Engineering area of the Rey Juan Carlos University, who were in charge of the coordination and design of the different activities of the project, in addition to acting as tutors in the different Bachelor Final Degree Projects developed within its framework. The project aims to address one of the most relevant social challenges today: mitigating the adverse environmental impact of urban areas through efficient management of solid waste comparable to domestic waste, promoting the achievement of the Sustainable Development Goals: 7-Affordable and clean energy, 11-Sustainable cities and communities; 12-Responsible consumption and production, in addition to proposing alternatives for obtaining bioenergy and bioproducts (compost) from them in a university educational context, therefore also aligning with SDG 4-Quality education.

Through this SL project, the aim is to adapt the waste plan of the Móstoles campus of the URJC to the new Waste Law with the objectives of:

• Raise awareness among the university population about waste minimization, the new criteria for separation at source, and the effect this can have on achieving quality recycling. This would be the service performed by the members of the service-learning project.

• Raise awareness of the selective collection of the organic fraction, which separated recolletation will be compulsory from July 2022 for local authorities with more than 5,000

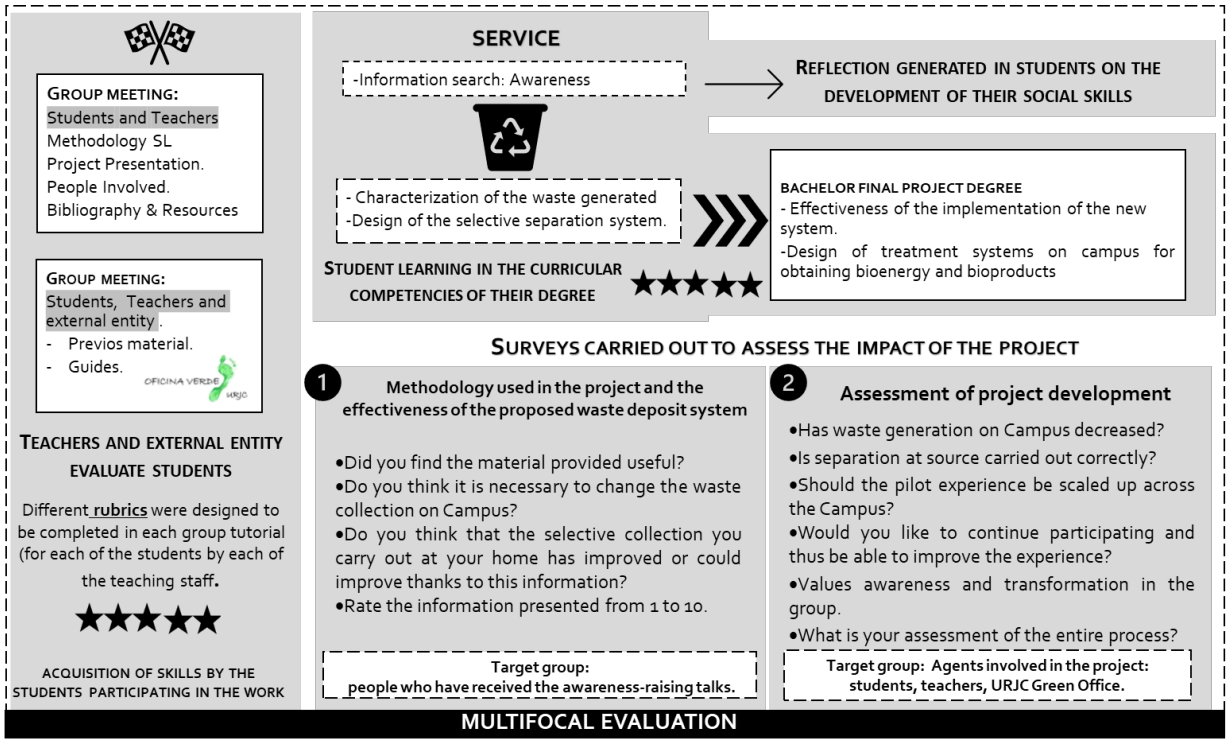
BY-NC-SA 2024, Editorial Universitat Politècnica de València

inhabitants. This would be the social need following the new Law on waste and contaminated soils for a circular economy.

• Development of technical alternatives for the valorization of the different waste fractions generated on the campus. Complying with the specific competencies of the Bachelor's Final Project Degree.

Figure 1 summarizes the stages of the project, which begins with meetings between students and teachers, to train participants in both the methodology and waste management. As an agent or external entity, the project has the collaboration of the green office of the university, which works to incorporate sustainability in any area of the URJC, already having material for students to begin developing their work and attending to the needs of the campus. Subsequently, containerization awareness and improvement services were carried out, and each of the students will develop their work on the subject of their discipline that aims to study the new containerization as well as the techno-economic design to convert this waste into bioproducts or bioenergy.

Fig. 1 –SL project & evaluation



Source: Own elaboration

One of the most characteristic parts of the SL methodology is the multifocal evaluation, it is a comprehensive approach that considers multiple dimensions to evaluate the effectiveness and impact of a project (Escofet, 2016). This evaluation was carried out by all project agents:

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Teachers, students, external organizations, and beneficiaries of the service. To this end, rubrics and surveys (Figure 1) have been used to collect the following information:

- Degree of acquisition of skills by the students participating in the work.
- Student learning in the curricular competencies of their degree.
- Reflection generated in students on the development of their social skills.
- Degree of compliance of service beneficiaries.

3. Results and discussion

3.1 Project development

The students of the different technological degrees were trained in the methodology and waste management, they proposed alternatives and were the protagonists in the awareness talks. They held 15 awareness talks for students (more than 250) in the building where the pilot project was implemented. They explained the concept of service-learning, the social need addressed, and the changes in the new containerization system. During these talks, participants showed graphic material that they prepared on the proper separation of waste; they also proposed different alternatives, such as energy recovery and transformation into bioproducts.

3.2. Acquisition of general competencies by the students

The teaching staff assessed the students through the use of different evaluation rubrics (Figure 1) in the different group and individual tutorials held with them. It is highlighted that all students have obtained grades higher than 3 in each of the general competencies evaluated. In some cases, an increase in their ratings is observed over time. The average of all skills ranges between 4.29 and 4.94 out of a maximum of 5.

3.3. Acquisition of specific competencies by the students

Likewise, the teaching team evaluated the acquisition of the specific competencies established in the Teaching Guides of each student's Bachelor Final Degree Project, in the case of energy engineering studies, the ability of the students to develop a work consisting of a project was evaluated. These students must prepare an original report or study linked to Energy Engineering in which the skills acquired throughout the degree are integrated. Specifically, designs of different alternatives were carried out to achieve valorization of the organic fraction generated on the campus (processes such as gasification or biomethanation). The degree of acquisition of this competence was evaluated with an average rating of 4 out of 5.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.4. Acquisition of social competencies by the students

The degree of acquisition of social competencies was evaluated by the teachers, the collaborating entity, and the students themselves, carrying out an evaluation of each member of the team, as well as a self-evaluation by the students. The teaching team evaluated the students' acquisition of social skills, following rubrics and awarding a score of 4.85 out of 5. This rating stands as the highest among all the skills developed during the SL RECICLANDO URJC project, underscoring its significant social impact. The students' self-assessment also reflects a remarkably positive perception of skill acquisition, with scores ranging from 4.40 to 5.0 out of 5. This outcome suggests that project participants believe they have gained social skills not typically developed in other types of final degree projects. Furthermore, students highlight that their involvement in this project allowed them to delve deeper into a complex contemporary societal issue. Additionally, while working on their final degree projects, they had the opportunity to engage in the techno-economic design of alternative solutions.

3.5. Degree of compliance of service beneficiaries

A survey was conducted to evaluate the methodology used in the project and the effectiveness of the proposed waste management system. The survey was completed by students who had participated in the training and awareness sessions as beneficiaries of the service. Unfortunately, the number of respondents was low, representing only 35% of the beneficiaries. However, considering that the survey was not linked to any theme and that it was sent several times, it could be considered that with this percentage of the population, conclusions can be drawn about the service provided. To this end, Figure 2 below summarises the results of the perception in different aspects.

Figure 2.- Compliance of service beneficiaries



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

The results revealed that 100% of the surveyed students positively valued the materials used in the awareness campaigns and acknowledged their understanding of source separation for solid household waste. Additionally, 92% of the students believed it was necessary to modify the waste containerization system on campus. Furthermore, 81% of the surveyed students reported an improvement in selective waste collection at their homes, attributed to the information received through the RECICLANDOURJC project. Overall, the information presented received an impressive assessment score of 8.9 out of 10, indicating a highly positive outcome

4. Conclusion

This project has demonstrated that the university can effectively address a significant social need through service-learning (SL) initiatives. University students, who previously lacked sufficient training in household waste management, have greatly benefited from the community service provided through awareness sessions, the creation of graphic materials, and the design and implementation of a new waste management system on campus. The beneficiaries of this service highly appreciate the positive contributions made by the students. Furthermore, during the execution of these tasks, participating students acquired essential general and social skills. As a result, the project had a tangible impact on the campus: waste separation significantly improved in one of the buildings at the Móstoles campus, directly benefiting the community. Additionally, proposals were developed to valorize the organic fraction of campus waste. As a consequence of these studies, an organic and vegetable composting system has been successfully installed within the campus. The project is expected to continue in different courses in order to be able to study the long-term effect, as well as to reach a larger number of beneficiaries.

Despite the additional effort required, the teaching staff expresses satisfaction with the project's results, confirming the heightened awareness among participating students regarding waste-related issues.

Acknowledgments

The development of this work was possible thanks to the calls for projects and financing of service learning projects of the Universidad Rey Juan Carlos 2022-2023 financed by the U. Office of Service Learning and the Vice-Rectorate of Planning and Strategy of the Universidad Rey Juan Carlos. As well as the " URJC BUSINESS CHAIR CIRCULAR ECONOMY FOR SUSTAINABLE WASTE MANAGEMENT", with which it was possible to attend the Congress.

(cc) BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bringle, R., & Hatcher, J. A. (1995). A Service-Learning Curriculum for Faculty. *Michigan Journal of Community Service-Learning*, *2*. Retrieved from https://scholarworks.iupui.edu/items/450f5213-cc4f-4267-aa79-7ee6e15b1719.

Estrategia Española de Economía Circular y Planes de Acción. (n.d.).,2024, from Gob.es website: https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia.html

BOE-A-2022-5809 Ley 7/2022, de 8 de abril, de residuos y suelos contaminados para una economía circular. (n.d.)., from Boe.es website: https://www.boe.es/buscar/act.php?id=BOE-A-2022-5809

Dale, A., & Newman, L. (2005). Sustainable development, education, and literacy. International Journal of Sustainability in Higher Education, 6(4), 351–362. doi:10.1108/14676370510623847

Escofet, A.; Folgueiras, P.; Luna, E. y Palou, B. (2016): «Elaboración y validación de un cuestionario para la valoración de proyectos de aprendizaje-servicio». Revista mexicana de investigación educativa, nº 21(70), pp. 929-949. https://www.scielo.org.mx/pdf/rmie/v21n70/1405-6666-rmie-21-70-00929.pdf>.

Gomes, S. F.; Jorge, S. y Eugénio, T. (2020): «Teaching sustainable development in business sciences degrees: evidence from Portugal». Sustainability Accounting, Management and Policy Journal, nº 12(3), pp. 611-634. https://doi.org/10.1108/SAMPJ-10-2019-0365>.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Emerging Tech for Future Experts: Unleashing the Potential of Generative AI in Sustainable Education

Dragan Vukmirovic[a], Tijana Comic[b], Nebojsa Stanojevic[c] and Uros Milicevic[d]

[a]Faculty of Organizational Science, University of Belgrade, Serbia
[b]MICS Global Team, UNICEF
[c]Ministry of Education, Science and Technological Development of the Republic of Serbia /Department, Serbia
[d]Ministry of Internal Affairs of the Republic of Serbia, Serbia

Abstract

In today's ever-changing education landscape, Generative Artificial Intelligence (Gen AI) is emerging as a game-changer, promising to reshape how we teach and learn, especially in the crucial field of sustainable education. This field demands critical thinking, innovative solutions, and a deep understanding of complex challenges. This paper explores the transformative impact of Gen AI in this area, looking at how tools like ChatGPT, Bard, and Bing can personalize learning and inject new life into traditional methods.

We acknowledge the possibilities Gen AI brings, but also critically examine the challenges – potential biases, the risk of misinformation, and the possibility of stifling creativity. We delve deep into practical strategies for integrating Gen AI responsibly in classrooms, emphasizing ethical usage and maintaining the integrity of education.

Our findings highlight the importance of continuous professional development for educators, collaboration among stakeholders, and crafting balanced curricula that blend AI tools with the development of essential cognitive skills. This paper aims to contribute to the conversation on sustainable education by offering actionable insights for educators and policymakers, advocating for a harmonious integration of Gen AI that enriches learning environments and empowers future energy experts.

Keywords: Generative AI, Sustainable Education, Artificial Intelligence in Education

How to cite: Vukmirovic, D; Comic, T; Stanojevic, N & Milicevic, U. (2024) Emerging Tech for Future Experts: Unleashing the Potential of Generative AI in Sustainable Education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 535-542. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

This paper examines Generative Artificial Intelligence (Gen AI), a subfield of Artificial Intelligence (AI) capable of creating human-quality content, within the context of sustainable education. Sustainable education emphasizes critical thinking, problem-solving, and comprehension of complex energy challenges. Tools like ChatGPT, Bard, and Bing have emerged, offering personalized learning experiences and potentially enriching student engagement and assessment processes (Grassini, 2023). However, integrating Gen AI into education presents challenges such as potential biases, information authenticity concerns, and the possibility of hindering critical thinking and creative skills (Michel-Villarreal et al., 2023).

This study aims to analyze these challenges and propose practical solutions. It focuses on enhancing a foundational understanding of Gen AI, its capabilities and limitations, and its ethical implementation in educational settings. Additionally, strategies for effective classroom integration and addressing privacy and ethical usage are explored. This analysis serves not only as an academic exploration but also as a practical guide for harmonizing technological advancements with educational practices. The goal is to equip future experts with the necessary skills and ethical awareness to leverage Gen AI in addressing global energy challenges.

2. State of the art

Generative AI represents a specialized branch of Artificial Intelligence focused on producing novel content, such as text, images, audio, or video, that rivals the caliber of materials created by humans. Within this domain, the role of ChatGPT can be paralleled to the revolutionary effect the World Wide Web had on the Internet. Just as the Web profoundly expanded the reach and usefulness of the Internet, transforming it into a global necessity, ChatGPT embodies a similar leap forward in the realm of AI. By making advanced AI technologies more accessible to a broader audience, ChatGPT serves as a key driver in promoting the widespread adoption and integration of AI into everyday tasks, thereby democratizing the power of Generative AI for public use. The development and operation of ChatGPT are grounded in a Large Language Model (LLM). This model has access to vast amounts of textual data (a massive "wall of blocks"), from which it learns through a mix of supervised and unsupervised learning techniques and complex algorithms to identify linguistic patterns in the training data. Fine-tuning generative AI models is an iterative process that may involve neural networks or other structures like transformers, depending on the specific capabilities needed. This process assesses the quality of generated outputs using metrics such as perplexity, BLEU scores, or human evaluations. These tools, or bots, are ultimately machines that do not learn abstract concepts and, unlike humans, lack an internal model to

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

comprehend the world around them. Therefore, human intervention is crucial, particularly in setting evaluation criteria and fine-tuning parameters, to ensure the model's alignment with intended objectives (Goldman Sachs, 2023).

3. Generative AI in Education

Historically, new technologies have been associated with increasing economic inequality and labor market disruptions, primarily affecting low-skilled and low-wage workers (Qureshi, 2020). Gen AI is expected to have a different impact, primarily affecting highly paid intellectual jobs, which are among the first to be impacted by Generative AI (Gmyrek et al., 2023). These jobs are often found in high-value, labor-intensive industries such as finance, education, and professional services (Ghosh et al., 2023). Major disruptions associated with job losses or potential economic gains from adopting new disruptive technologies in these industries could quickly spread across the entire labor market (Dwivedi et al., 2023).

Educators are not immune to these changes. A study by Santander identified Middle School Teachers (excluding Special and Career/Technical Education) as among the top ten professions most susceptible to changes brought about by language modeling in the USA, considering only those occupations with over 50,000 workers (Moro & Frank, 2023).

The integration of AI and tools like Gen AI can significantly impact reducing inequalities in schools and colleges. Using AI technology directly influences the promotion and implementation of inclusive education approaches, advocating for equal educational opportunities for all students, regardless of their physical, intellectual, social, emotional, linguistic, or other differences (Kamalov et al., 2023).

Here's how Gen AI technology can support inclusive education (among other things):

- **Personalized learning**: AI enables the creation of adaptable learning experiences that match individual learning styles and abilities. By analyzing students' learning patterns, AI can customize educational materials, enhancing the learning experience.
- **Support for students with special needs**: AI-based tools can offer specially designed programs for students with learning difficulties, speech and language barriers, and physical limitations.
- **Increased accessibility of educational materials**: Technology can enhance the availability of educational materials through digital platforms, including accessible formats like e-books, audiobooks, and videos with subtitles or sign language.
- **Empowering students through technology**: The use of technological tools allows students to take greater control of their learning, fostering independence and confidence essential for inclusive education.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- **Breaking down language barriers**: Technology helps bridge language gaps for non-native speakers, providing translations and linguistic support for better understanding and inclusion.
- **Encouraging collaboration and understanding**: Collaborative tools and platforms promote inclusivity by encouraging students from diverse backgrounds to work together on projects, fostering mutual respect and understanding.

By adopting such applications, technology directly contributes to the goals of inclusive education, ensuring that the education system adapts to every student's needs rather than students having to meet the rigid requirements of the educational system. This creates a more inclusive, equitable, and efficient educational environment for all.

4. How generative AI could be applied in sustainable energy education - Case Study Serbia

There is significant debate in the Serbian public about whether electric vehicles (EVs) are as energy-efficient and "clean" as they are portrayed to be compared to combustion engine vehicles. The most common argument is that electricity is expensive compared to fossil fuels and that generating the electricity needed to power EVs in Serbia would require additional reliance on coal-fired power plants, further harming the environment.

Debating the energy efficiency and environmental impact of electric vehicles (EVs) versus internal combustion engine (ICE) vehicles can be an educational and enlightening experience for students, especially in the context of Serbia's energy landscape. Generative AI, such as AI-based debate facilitation tools or information aggregation systems, can play a significant role in this debate by providing data-driven insights, generating hypothetical scenarios, and ensuring that arguments are based on up-to-date and comprehensive information.

The authors designed the debate not only to educate students about generative AI, sustainable energy, and the associated technological and policy challenges but also to equip them with the critical thinking and analytical skills necessary to navigate and contribute to these important global discussions.

Here's how ChatGPT 4 structure the debate and the role of generative AI in it:

Structure of the Debate:

1. **Team formation**: Form two teams - a random sample of 30 first-year students from the Faculty of Organizational Sciences leveraging their high school knowledge in environmental science, economics, or technology. These students were randomly divided into two groups to participate in a debate: one supporting the statement that EVs are not as energy-efficient or environmentally friendly as portrayed, especially in Serbia's context; and the other opposing this viewpoint.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. **Pre-debate preparation**: ChatGPT 4 is used to gather and synthesize relevant data and studies on EVs, ICE vehicles, Serbia's energy production, and environmental implications. This data can help both teams prepare their arguments.

3. **Role of Chat GPT during the Debate**: ChatGPT 4 is used to fact-check statements in real-time, provide statistical data, generate hypothetical environmental impact models based on Serbia's energy mix, and even suggest counterarguments or new perspectives to each team.

4. **Moderation**: ChatGPT also help in moderating the debate by timing each segment, ensuring adherence to the rules, and summarizing key points from each team.

Questions for each team:

Team Supporting the statement (Pro-EV Skepticism):

1. Environmental Impact: How does the reliance on coal-powered electricity in Serbia impact the overall environmental benefits of EVs?

2. Life Cycle analysis: Can you discuss the life cycle emissions of EVs, including manufacturing and battery production, compared to traditional ICE vehicles?

3. Economic aspect: Considering the current cost of electricity and fossil fuels in Serbia, how do you justify the economic efficiency of EVs?

4. Energy infrastructure: What challenges does Serbia's current energy infrastructure pose for widespread EV adoption?

5. Future projections: How might advancements in renewable energy sources affect your stance on EVs in the future?

Team Opposing the statement (Pro-EV Advocacy):

1. Long-term benefits: How do the long-term environmental and economic benefits of EVs compare to ICE vehicles, despite Serbia's current energy mix?

2. Renewable energy transition: How could the gradual transition to renewable energy sources enhance the effectiveness of EVs in Serbia?

3. Global trends: How do global trends in EV efficiency and renewable energy adoption impact the debate in the Serbian context?

4. Technological advancements: How might future advancements in EV technology and battery efficiency change the current scenario in Serbia?

5. Policy and incentives: What kind of government policies or incentives could accelerate the transition to a more EV-friendly environment in Serbia?

The key points from the debate are summarized in the following statements:

The **Pro-EV Skepticism** team highlighted several concerns. They argued that EVs' environmental impact is negatively skewed due to Serbia's heavy reliance on coal-powered electricity, suggesting a potential reduction in the environmental benefits of EVs. However,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

they acknowledged that life cycle emissions of EVs could be comparable to Internal Combustion Engine (ICE) vehicles when renewable energy sources are considered. Economically, they deemed EVs not currently cost-effective within Serbia's economic landscape. Despite these criticisms, they saw Serbia's energy infrastructure as capable of supporting EV adoption with feasible, targeted investments, though they remained cautious, noting that future projections for EVs are heavily dependent on global trends in energy and technology.

Conversely, the **Pro-EV Advocacy** team presented a more optimistic view. They argued that EVs offer superior long-term environmental and economic benefits compared to ICE vehicles, especially with a transition towards renewable energy, which they deemed essential for maximizing EV benefits. They recognized global trends as increasingly favorable for EVs, though they conceded that progress depends on policy and technological advancements. The team was adamant that technological advancements are critical for overcoming EVs' current limitations and that government policies and incentives could significantly accelerate EV adoption in Serbia.

This debate not only showcased the students' ability to apply their prior knowledge to a complex, real-world issue but also reflected the nuanced perspectives surrounding the adoption of EVs in Serbia. Both teams effectively utilized generative AI to bolster their arguments with data and projections, indicating a thoughtful consideration of the multifaceted challenges and opportunities that EV adoption presents.

HHowever, this novel approach introduces challenges, such as ensuring the accuracy and neutrality of the AI-generated data and the need for participants to critically assess AI contributions. Table 1 serves as a guide to address specific challenges associated with using generative AI in educational debates. It outlines practical strategies for educators to enhance the learning experience and ensure that students not only benefit from the technology but also develop critical thinking skills and a deep understanding of complex issues.

Thus, while Generative AI acts as a powerful tool to navigate and illuminate complex issues, its application demands careful moderation to harness its benefits fully while mitigating potential drawbacks, ensuring debates remain a fertile ground for human insight and intellectual growth.

A significant outcome of this debate was the faculty's development of a comprehensive policy for the utilization of Generative AI across educational and administrative spheres. This initiative not only demonstrates the faculty's commitment to embracing technological advancements but also establishes a framework for responsible AI use that can serve as a model for other educational institutions navigating similar transitions.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Table 1 – Specific challenges associated with using generative AI in educational debates

Challenges	Mitigating Strategies	Role of Educator
Lack of contextual knowledge	Provide detailed preparatory material and sessions	Guide students through the preparatory materials, ensuring they understand the context and relevance of the debate topic.
Overreliance on AI for data and arguments	Teach students to critically evaluate AI-generated information	Emphasize critical thinking and the importance of independent research, providing exercises to verify AI-generated data.
Inadequate prior knowledge	Specify prerequisite courses or knowledge areas	Assess students' readiness and provide resources or remedial sessions to fill knowledge gaps.
Bias in AI-generated content	Include lessons on identifying and understanding bias in AI systems and data sources.	Lead discussions on AI bias, how it can influence debate arguments, and ways to counteract biased information.
Difficulty in fact-checking AI Statements	Incorporate real-time fact-checking tools and techniques into the debate preparation process.	Demonstrate the use of fact-checking tools and techniques, guiding students on how to effectively apply them during the debate.
Lack of engagement in critical thinking	Design debate formats that reward critical analysis and the questioning of sources, including AI-generated content.	Foster an environment that values inquiry and skepticism, encouraging students to question and critique all forms of information.
Unclear evaluation criteria	Develop clear rubrics that include assessment of critical thinking and effective use of AI	Communicate evaluation criteria, ensuring students understand how their performance will be judged.
Navigating technological challenges	Offer training sessions on the use of generative AI tools and platforms relevant to the debate.	Provide technical support and resources, ensuring all students are proficient in using the required technology.

Source: Own elaboration

6. Conclusion

While powerful tools like ChatGPT unlock possibilities for personalization and automation, their magic lies in freeing educators to cultivate the critical thinking, creativity, and collaboration skills our future depends on.

Let's not forget, the human touch remains irreplaceable. Policymakers must create responsible guardrails, and educators need ongoing support to harness this technology's power (Vukmirovic et al., 2023). Collaboration across educators, technologists, and students is key. By sharing experiences and fostering continuous learning, we can build an education system that's responsive, inclusive, and leverages AI to enrich the sustainable education landscape.

Ultimately, we hope to equip educators and policymakers with the knowledge and tools to integrate Gen AI responsibly, paving the way for a generation of energy experts who are knowledgeable, prepared, and ethically driven.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Ghosh, B., Wilson, H. J., & Castagnino, T. (2023). GenAI Will Change How We Design Jobs. Here's How. Harvard Business Review. https://hbr.org/2023/12/genai-will-change-how-we-design-jobs-heres-how

Gmyrek, P., Berg, J., & Bescond, J. (2023). Generative AI and jobs: A global analysis of potential effects on job quantity and quality. ILO, https://www.ilo.org/static/english/intserv/working-papers/wp096/index.html

Goldman Sachs. (2023). *Generative AI: Hype, or truly transformative*? Goldman Sachs Research. https://www.goldmansachs.com/intelligence/pages/top-of-mind/generative-ai-hype-or-truly-transformative/report.pdf

Grassini, S. (2023). Shaping the Future of Education: Exploring the Potential and Consequences of AI and ChatGPT in Educational Settings. Education Sciences. 13(7):692. https://doi.org/10.3390/educsci13070692

Kamalov, F.; Santandreu Calonge, D.; Gurrib I. (2023). New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. Sustainability 2023, 15, 12451. https://doi.org/10.3390/su151612451

Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro D.E., Thierry-Aguilera, R, & Gerardou, F.S. (2023). Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT. Education Sciences. 2023; 13(9):856. https://doi.org/10.3390/educsci13090856

Moro, E., & Frank, M. R. (2023). Transformative potential of generative AI: Innovation, impact, and implications for the future workforce. Santander Group. https://www.santander.com/content/dam/santander-com/es/contenido-paginas/landing-pages/santander-x-xperts/do-santander-x-xperts-Transformative%20potential%20of%20generative%20AI.pdf

Qureshi, Z. (2020). Technology and the future of growth: Challenges of change. Brookings. https://www.brookings.edu/articles/technology-and-the-future-of-growth-challenges-of-change/

Vukmirović, D., Popovac, R., Stanojević, N. & Čomić, T. (2024). Challenges of integration and implementation of generative artificial intelligence in the process of higher education. CCHE 2024.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Promoting Energy Sustainability in ICT

Consolación Gil[a], Fernando Martínez[b], Jorge Ventura[b], Viktor Isanbaev[b], Raúl Baños[b], and María G. Montoya[a]

[a]Department of Informatics, Ciambital, University of Almería, Spain
[b]Department of Engineering, Ciambital, University of Almería, Spain

Abstract

In this study, we propose a program aimed at enhancing awareness of energy sustainability among future secondary school teachers, with a specific focus on energy consumption associated with the use of Information and Communication Technologies (ICT). Various studies highlight the exponential growth of CO_2 emissions within the ICT sector. Daily practices, such as leaving chargers connected to the electrical grid, sending emails with large attachments, excessive streaming or video usage, and even seemingly simple actions like sending stickers in messaging applications, contribute to unnecessary energy consumption. To address this issue, we employed a quantitative methodology, incorporating an initial questionnaire to comprehend participants' ICT usage habits and their existing level of awareness. Throughout the intervention, participating students engaged in various activities related to energy sustainability while gaining knowledge about relevant concepts and computer tools essential for their future teaching roles. Subsequently, a follow-up questionnaire was administered at the conclusion of the program to evaluate the impact on awareness regarding energy-saving practices in ICT usage. The findings demonstrate that even with minimal interventions, a substantial increase in awareness was observed among the majority of students. Furthermore, this approach holds the potential for exponential impact, as a significant number of participants expressed their readiness to implement similar awareness activities among their future secondary school students.

Keywords: sustainability; ICT; energy consumption awareness; education.

How to cite: Gil, C.; Martínez,F.; Ventura,J.; Isanbaev,V.; Baños,R. and Montoya, M.G. (2024) Promoting Energy Sustainability in ICT. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 543-551. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Sustainable development refers to meeting the needs of the present without compromising the ability of future generations to meet their own needs. The Sustainable Development Goals (SDGs) (United Nations, 2015) aim to promote sustainable consumption and production. This involves promoting the efficient use of resources, energy and materials, as well as the adoption of sustainable practices in companies and among individuals. The aim is to reduce environmental impact, minimize waste and preserve resources for future generations. This approach not only benefits the environment, but can also create economic opportunities and improve quality of life (United Nations, 2015).

Sustainability and efficient management of environmental resources also affect the Information and Communication Technology (ICT) sector. Its study is interesting from the perspective of the increasing energy consumption of large data centers, as well as its contribution to reducing the ecological footprint, leading to concepts such as "Green IT", "Green Computing" or "Green Algorithms" (Murugesan, 2008).

On one hand, digital transformation generates high demand at the user and business levels, as well as an increasing demand for data and processing capacity in energy-consuming data centers (García de Madariaga Miranda et al., 2019). This demand for information and communications is associated with an increase in energy consumption. Currently, ICT represents a global consumption of approximately 7% of electricity. It is expected to rise to 13% by 2030. This consumption translates to a figure between 3% and 5% of CO_2 emissions, comparable to the aviation sector (de Eusebio et al., 2023). Therefore, one of the major challenges for the sector in the coming years is to improve its efficiency and produce its own renewable energy. In this regard, Green IT represents the technology sector's commitment to sustainability and energy efficiency, encompassing actions aimed at minimizing the environmental impact of technology production (Murugesan, 2008).

On the other hand, ICT also contributes to reducing the ecological footprint in many sectors of human activity (Belkhir & Elmeligi, 2018), such as transportation, buildings through home automation and intelligent energy management, or smart cities with waste management through smart containers that notify when full, creating optimal and efficient routes to save time and money, and lastly, through the optimization of technological devices, as some devices or computer equipment now require less than 50% of the energy compared to previous years (Aebischer & Hilty, 2015).

We must not forget that both the number of Internet users and social media users has grown at an astonishing rate. For example, the number of Internet users has surged from 16 million users in 1995 to over 5.5 billion in 2022, with Africa experiencing the highest growth in 2022 (+39%), while in Europe, it has increased by 25%. Focusing on internet use at the user level,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

on average in 2021, every minute, 451 million WhatsApp messages sent worldwide, 188 million emails sent, 452,000 hours of Netflix viewed, 5.7 million videos on YouTube, and 6.1 million searches on Google, according to data published in Visual Capitalist (Ali, 2021).

But most users are not aware that all the data generated as we navigate the web is stored in a physical location: data centers. These data centers require large amounts of energy to operate, cool down, and prevent overloading (Whitehead et al., 2014). The servers and supercomputers that keep us connected 24/7, working tirelessly, needed over 400 terawatts of energy in 2019. It is projected that by 2030, data centers will consume 20% of global energy.

To grasp the current scale of these data centers, consider that Google's search engine processes up to 9 billion searches per day and is increasingly leaning towards artificial intelligence (AI). If every Google search involved AI, it would require about 29.2 terawatt-hours of energy every twelve months, equivalent to the entire annual electricity consumption of a country like Ireland (de Vries, 2023).

Regardless of the controversial neutrality of ICT, any initiative aimed at educating or raising awareness for a more sustainable use of them would contribute to better utilization of the planet's energy resources. Thus, within various awareness initiatives, (de Eusebio et al., 2023) observed that public universities have made greater efforts to educate the Spanish population about the material consequences of ICT, although the environmental impact of ICT consumption was the least addressed area in these initiatives.

The study by (Angelaki et al., 2023) aimed to enhance sustainability awareness among ICT degree students over a two-week period. The research demonstrated a significant direct impact of educational intervention on students' intention to engage in sustainability. The findings emphasize the need for conscientious digital consumption, highlighting the necessity of critical and literate citizens to address the challenges of collective behavior.

This intervention seeks to enhance awareness and sensitize prospective secondary education teachers regarding the significance of adopting responsible behaviors to mitigate the energy consumption linked with ICT usage. Simultaneously, without portraying ICT negatively, it aims to foster an understanding of the potential contribution of ICT in diminishing environmental resource utilization and, consequently, global CO_2 emissions. This holds significance for two key reasons. Firstly, the awareness instilled in each student (aspiring secondary education teacher) can propagate this message to numerous teenage students once they assume teaching roles, as teenagers presently heavily engage in messaging apps, video or series streaming, and the sharing of photos or videos on social networks. Secondly, the awareness cultivated in these students can, in turn, influence their families and

BY-NC-SA 2024, Editorial Universitat Politècnica de València

immediate circles, fostering conscious digital consumption through a citizenship characterized by critical awareness and literacy.

Therefore, we will focus on raising awareness about ICT consumption at the user level in subjects within the Master's in Secondary Education. Firstly, we will analyze the most common habits among young people, and subsequently, we will develop activities to raise awareness and educate on the proper use of devices and applications to reduce the energy consumption of ICT.

2. Methodology

The intervention was conducted in two elective courses within the Secondary Education Teaching Master's program at the University of Almería. These courses are the only subjects that develop the digital competence of future teachers. These courses encompass various topics related to the use of ICT resources, such as Learning Management System (LMS) platforms, Google Classroom applications, and methodological aspects of teaching and learning. It is noteworthy that, given their elective nature, students from diverse specialties enroll in these courses, and they are not specifically tailored for those pursuing ICT degrees.

The methodology employed adopts a quantitative approach to gather information about the knowledge and awareness of future teachers regarding the use of ICT. Initially, a pre-intervention questionnaire was used to analyze the common habits of young individuals (pre-test questionnaire in Table 1). Through certain questions in this questionnaire, we also gain preliminary insights into the environmental concerns stemming from the heightened energy consumption in large data centers managing concurrent operations. Subsequently, academic activities were implemented to raise awareness and educate on the proper use of ICT devices and applications for six weeks. Finally, a post-questionnaire (Table 1) was administered to assess the intervention's outcomes and analyze the significance of integrating sustainable practices in the use of ICT in education.

Pre-questionnaire (Table 1) utilizes a four-response scheme, which varies slightly across some items. Items 1, 2, and 9 employ the following scale: constantly, several hours a day, occasionally, never. This scale varies slightly for items 4, 5, 6, and 7, using: always, most of the time, occasionally, never. Item 3 employs a different scale to gather information about usage hours: more than 3 hours, between 2 hours and 3 hours, between 1 hour and 2 hours, less than 1 hour. Finally, items 8, 10, and 11 adapt to a short-answer format: yes, no.

Post-questionnaire (Table 1) utilizes a four-option Likert scale (I totally disagree, I disagree, I agree, I totally agree) for all items except item 10. In this item, four alternatives are provided to reduce their carbon footprint: send fewer gifs, spend less time watching non-priority content videos, spend less time on social media, upload less content to social media.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2.1 Awareness Activities on Energy sustainability in ICT

The courses incorporated a series of awareness activities emphasizing the integration of sustainable practices in ICT use for education.

Table 1 – Structure of the first (pre-test) and final (post-test) questionnaire

Item	Pre-test questionnaire	Post-test qustionnaire
1	How often do you use electronic devices such as mobile phones, tablets, or computers in your daily life?	My knowledge about environmental sustainability in aspects such as recycling, overall energy consumption, pollution, plastic usage, and food waste was significantly higher than the knowledge about energy consumption due to the use of ICT.
2	Do you use social media daily?	My perception of the impact of excessive use of ICT on energy sustainability has changed after completing the various proposed activities.
3	how much time do you spend on them each day?	The activities carried out in class on sustainability in ICT have been instructive and have allowed me to learn information about aspects that I was previously unaware of.
4	How often do you turn off your electronic devices when you are not using them?	Working in cooperative teams has helped me to know and understand different points of view on the topic of sustainability in ICT, while enriching my current perspective.
5	How often do you avoid printing large documents?	The escape room activity has been fun and has allowed me to conduct additional research when formulating my five challenges
6	How often do you compress or reduce the size of PDF files and photos?	The activities carried out in cooperative teams, such as the Blog, the Webquest, and the escape room, have provided me with suggestions to implement similar activities with my future students
7	How often do you avoid sending heavy emails and instead use web links?	I am willing to reduce the time I spend on social media and other non-essential uses of electronic devices to contribute to environmental sustainability.
8	Have you heard of the "carbon footprint"?	I am willing to reduce the number of stickers and gifs I include in my messages to contribute to the reduction of CO_2 emissions.
9	Have you ever considered how intensive use of electronic devices can impact energy consumption and CO_2 emissions?	80% of the emails sent daily go unopened. Deleting those emails (and the trash) from my inbox regularly, I would significantly reduce my environmental impact. I am willing to delete unnecessary emails.
10	Sending each sticker or gif in applications like WhatsApp results in an emission of approximately 0.120 grams of CO_2. Given that around 65 million WhatsApp messages are sent daily, assuming one sticker or gif is included for every 10 messages, are you surprised to learn that this amounts to an emission of about 296 tons of CO_2 per year?	If you had to halve your carbon footprint, what actions do you think you could take?
11	Would you like to learn more about reducing your carbon footprint by using technology more sustainably?	I am willing to share my knowledge about sustainability in the use of ICT with my future secondary school students.

Source:Author.

As a key component of the course, students were tasked with creating a Moodle course in their respective specialties for their future students. To simulate real-world teaching

BY-NC-SA 2024, Editorial Universitat Politècnica de València

scenarios, each student enrolled a small group of their peers (2 or 3) in their Moodle course, allowing all students to assume the dual roles of teacher and student. Notably, the course content was enriched with ICT sustainability concepts, and new activities were introduced, focusing on cooperative work and gamification. The following examples illustrate how these activities were tailored to encompass ICT sustainability concepts:

Activity 1: Students, acting as teachers, designed an activity within their Moodle course, instructing their peers to read an article on ICT sustainability. Subsequently, each student was required to submit a report based on the article, and the student in the teacher role provided feedback and assessment.

Activity 2: Students, in their role as teachers, created a blog for their peers, initiating a discussion on the environmental impact of email usage and proposing measures to reduce carbon footprint.

Activity 3: Students, as teachers, developed a webquest for a cooperative group of 3 students, focusing on the use of Internet of Things (IoT) to improve energy consumption through ICT. The goal is to show how ICT also helps improve environmental sustainability through, for example, smarter cities and homes to save energy consumption or connected transport to improve routes and save fuel.

Activity 4: Students, in their role as teachers, designed an escape room activity centered on the concept of "Digital Waste," challenging their peers to identify and address redundant information and its environmental implications.

3. Results and Discussion

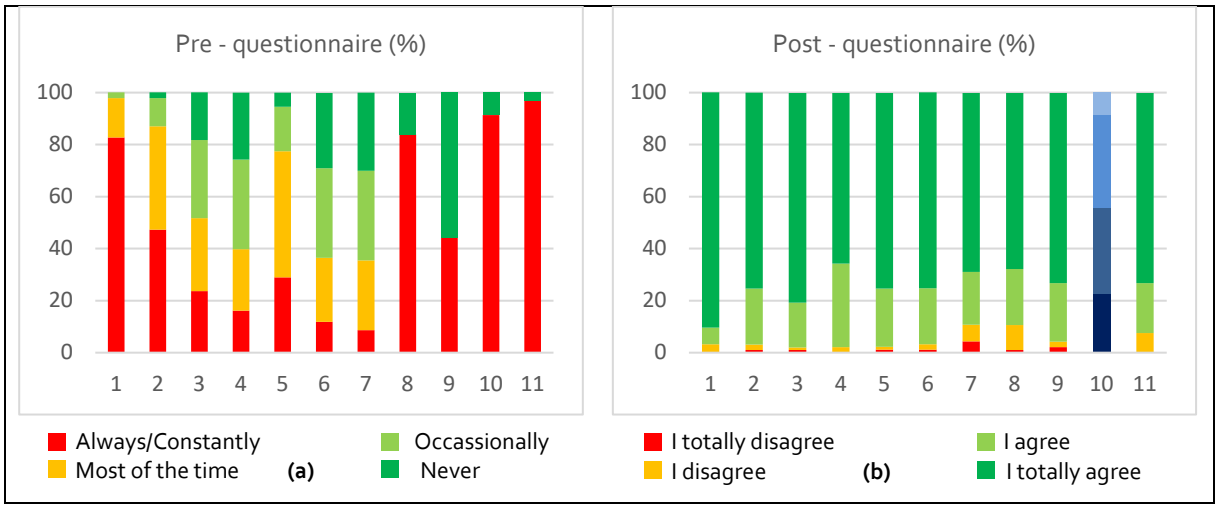
The two questionnaires were filled out by ninety-three students: fifty-seven women (61.3%), thirty-five men (37.6%), and one respondent identifying as another gender or others (1.1%). The students were predominantly young, with 46.2% aged between 22–24, 24.7% aged 25–27, 7.5% aged 28-30, and 21.5% older than 31. Additionally, students hailed from various degree programs, including Hispanic Philology (16.1%), English Philology (3.2%), Mathematics (9.7%), Biology (9.7%), Geography and History (10.8%), Physical Education (6.5%), Economics (16.1%), Drawing (6.5%), Technology (9.7%), and others (6.4%).

Figure 1 (a) displays the students' responses to the pre-questionnaire presented in Table 1. The results indicate that approximately 98% of students dedicate a significant portion of their daily hours to using ICT devices and applications. Additionally, over 50% report spending more than 2 hours daily on social media. About 83% are familiar with the concept of a carbon footprint and have prior knowledge of environmental sustainability issues. However, approximately 60% are unaware of the impact of ICT use on energy consumption and CO_2 emissions. In fact, over 60% usually do not turn off electronic devices or replace sending

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

heavy files with links in emails. Conversely, while approximately 80% of students avoid printing on paper, over 90% of students were surprised to learn that stickers or gifs sent in messaging applications can consume significant amounts of energy resources, considering the number of people simultaneously sending messages worldwide. Additionally, 97% of students expressed interest in continuing to learn about sustainability aspects in ICT.

Fig. 1 – Pre-questionnaire (a) and Post-questionnaire (b) results



Source: Author

Figure 1 (b) presents the students' responses to the post-questionnaire, which was conducted at the conclusion of the course and is detailed in Table 1. The results reveal that, while students had prior knowledge of environmental sustainability topics such as recycling, general energy consumption, plastic use, and food waste, they were less aware of how the increasing use of ICT is influencing worldwide energy consumption. This suggests a need for further education on the environmental impact of ICT usage.

Regarding the activities conducted in class, students express that these activities have been highly instructive, providing them with new insights into topics they were previously unfamiliar with. The majority also agree that engaging in cooperative work during certain activities has been beneficial for comprehending diverse perspectives and exploring a broad spectrum of possibilities and alternatives presented by their peers. They find the escape room activity particularly thrilling, as it has encouraged them to seek additional information to formulate their own challenges. For instance, one student's escape room narrative began with the following text: "A hacker named 'Terabyter' has overwhelmed the network, and the only means of communication is through simple messages or lightweight files. Your task is to identify situations where redundant or unnecessary information can be eliminated, allowing the network to stop being overloaded and basic services to function (hospitals or educational institutions)".

BY-NC-SA 2024, Editorial Universitat Politècnica de València

They also expressed interest in the webquest activity, which delves into aspects of the positive impact of ICT on energy conservation by envisioning the creation of intelligent cities. The majority of students find these activities highly motivating and plan to incorporate them into their future roles as secondary education teachers.

Lastly, it is noteworthy that more than 89% of the students exhibit a willingness to curtail their time spent on social networks, as well as reduce the usage of stickers and gifs in their messages. Furthermore, they express a readiness to contribute to the mitigation of digital waste by actively managing unnecessary emails in their inbox (95%). When prompted to engage in actions aimed at reducing their carbon footprint by half, their preferences for actions vary based on the time commitment to each application. The provided options included sending fewer gifs (22%), spending less time on non-priority content videos (33%), reducing time spent on social media (35%), and uploading less content to social media (8.6%). Their choices indicate that, as individuals beyond their teenage years, they allocate less time to uploading content to social networks, perceiving it as the area where the need for reduction is least pressing. Finally, 93% of the students express their readiness to share these insights with their future students in secondary education.

4. Conclusions

Information and Communication Technologies (ICT) demand substantial resources and energy for the production and operation of the infrastructure supporting digital data usage and electronic devices. Therefore, entities engaged in data transmission, processing, and storage must optimize their digital infrastructures for energy efficiency. Addressing the issue of energy consumption in the ICT sector necessitates a multidisciplinary effort involving various fields, with education playing a crucial role (de Eusebio et al., 2023). In our society, there is a need for heightened awareness regarding the vast amount of information generated by electronic devices. Often, the average user remains unaware of the daily accumulation and storage of this information and its associated environmental impact (de Vries, 2023). Consequently, initiatives aimed at raising awareness become imperative.

This study introduces an intervention aimed at fostering energy sustainability awareness while imparting essential concepts and practical computer tools for prospective teaching roles. It is crucial to note that there have been no modifications to the curriculum or subject programs. The research employed a quantitative methodology, utilizing an initial questionnaire to capture insights into ICT usage habits and a follow-up survey to evaluate the intervention's impact. The study's outcomes reveal that even with minimal interventions, there is a notable and direct positive effect on students' intention to engage in sustainability. This positive response suggests the potential for exponential growth, as students show a

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

favorable attitude toward integrating sustainability awareness activities into their future endeavors as secondary education teachers.

Acknowledgements

This work has been supported by project 23_24_1_26 of the University of Almería.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Aebischer, B., & Hilty, L. M. (2015). *The Energy Demand of ICT: A Historical Perspective and Current Methodological Challenges* (pp. 71–103). https://doi.org/10.1007/978-3-319-09228-7_4

Ali, A. (2021). *From Amazon to Zoom: What Happens in an Internet Minute In 2021? Visual Capitalist*. https://www.Visualcapitalist.Com/from-Amazon-to-Zoom-What-Happens-in-an-Internet-Minute-in-2021

Angelaki, M. E., Bersimis, F., Karvounidis, T., & Douligeris, C. (2023). Towards more sustainable higher education institutions: Implementing the sustainable development goals and embedding sustainability into the information and computer technology curricula. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-12025-8

de Eusebio, J. G., Fernández, F. T., de Madariaga Miranda, J. M. G., & Mariño, M. V. (2023). Good practices to demystify the environmental neutrality of information and communication technologies | Buenas prácticas para desmitificar la neutralidad ambiental de las Tecnologías de la Información y de la Comunicación. *Observatorio*, *17*(1), 58–74. https://doi.org/10.15847/OBSOBS17120232090

de Vries, A. (2023). The growing energy footprint of artificial intelligence. *Joule*, *7*(10), 2191–2194. https://doi.org/10.1016/j.joule.2023.09.004

García de Madariaga Miranda, J. M., Tucho Fernández, F., González de Eusebio, J., & Vicente Mariño, M. (2019). Concienciar en sostenibilidad tecnológica: experiencias comunicativas y educativas en España para un uso sostenible de las TIC. *COMMONS*, *8*(2), 41–79. https://doi.org/10.25267/COMMONS.2019.v8.i2.02

Murugesan, S. (2008). Harnessing Green IT: Principles and Practices. *IT Professional*, *10*(1), 24–33. https://doi.org/10.1109/MITP.2008.10

Whitehead, B., Andrews, D., Shah, A., & Maidment, G. (2014). Assessing the environmental impact of data centres part 1: Background, energy use and metrics. *Building and Environment*, *82*, 151–159. https://doi.org/10.1016/j.buildenv.2014.08.021

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Campus decarbonization challenge learning experience

Raquel Martín López[a], María Calero Pastor[b], Carla de Paredes Gallardo[c], Héctor Espinós Morató[b], Luz Martínez Musoles[a] and Sofía García Manglano[b].

[a]Department of Business, Faculty of Social Sciences, European University of Valencia, Spain.

[b]Department of Science, Engineering, and Design, Faculty of STEAM, European University of Valencia, Spain.

[c]Legal Department, Faculty of Social Sciences, European University of Valencia, Spain.

Abstract

Although sustainability has already permeated the minds of young people, there is still a gap between knowledge and acting, towards achieving behavioural changes that benefit the environment. As influential societal institutions, universities must lead by example, engaging their community in decision-making. This article explores how experiential learning can improve connections between intentions and implementation of sustainable practices, enhance the university's societal role, and democratize decision-making processes towards a decarbonized urban campus. It aims at fostering sustainability through a challenge learning experience focused on a multidisciplinary framework that includes engagement with the business sector. The ultimate goal is to increase awareness and behavioural change on sustainable development throughout the university. The methodology includes quantitative and qualitative assessments through questionnaires to students and interviews with collaborating enterprises. The results indicate that such experiential learning initiatives significantly raise awareness and foster real-world problem-solving skills among students. Particularly, this approach enhances their understanding of sustainability challenges and empowers them to actively participate in developing practical solutions. This not only educates them about environmental issues but also equips them with the tools to effect tangible changes within their communities. By integrating business, science, engineering, and design, this experiential method promotes a holistic understanding and comprehensive engagement with sustainability, ultimately preparing students for future professional challenges while actively contributing to the university's sustainability goals.

Keywords: higher education; carbon footprint; sustainability; commitment; enterprises.

How to cite: Martín López, R.; Calero Pastor, M.; de Paredes Gallardo, C.; Espinós Morató, H.; Martínez Musoles, L. and García Manglano S. (2024) Campus decarbonization challenge learning experience. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 552-560.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Despite the widespread discourse on sustainability, there remains a significant gap between what is learned and acting. This highlights a lack of genuine commitment and the need to tackle the disconnection between intentions and implementation.

As influential institutions within society, universities have a responsibility to lead by example. This has an influencing effect on stakeholders such as, investors, public administrations, and the wider educational community. By implementing sustainable measures, they not only fulfil their societal responsibility but also inspire broader systemic change. In addition, universities must consider the perspectives and preferences of their community such as students, faculty, and staff. Failure to engage these stakeholders in decision-making processes can lead to resistance to sustainability initiatives. Empowering students to propose and implement sustainability measures can foster a sense of ownership and ensure initiatives aligned with the needs and aspirations of the campus community.

The present article explores how experiential learning can bridge these problems, fostering genuine commitment, enhancing the university's societal role, and democratizing decision-making processes towards a decarbonized urban campus.

The European University (Universidad Europea) is recognised by its academic model focused on experiential learning. One of the most significant characteristics of experiential learning is its facilitation of direct engagement between students and the subject matter, thereby enabling effective integration of theory and practice (Romero, 2010). This interaction between conceptual knowledge and practical application not only enriches the student's educational experience but also promotes more enduring learning. Moreover, experiential learning influences cognitive improvement and the modification of values, attitudes, and perceptions (Escolano et al., 2016).

Towards the end of the 1990s, environmental education and sustainability started to become more significant in university curricula (Coya, 2011). The educational setting for students is viewed as a crucial factor in fostering a shift towards sustainability, by promoting an understanding of ecological boundaries and sustainable interactions within the ecosystem (García & Vergara, 2000).

The primary objective of this document is to advocate for sustainability through an educational strategy that focuses on experiential learning within a multidisciplinary framework and includes engagement with the business sector. The ultimate goal is to extensively enhance awareness of sustainable development throughout our university.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Experiential Learning

Experiential learning seeks to construct knowledge through real-world experiences and subsequent reflection (Gleason Rodriguez & Rubio, 2020). David Kolb's proposed a model of learning grounded in experience and adaptable to contemporary learning challenges (Luna & Valdés, 2027). His contribution has sparked heightened interest in experiential learning and increased involvement from professionals in higher education (Smith, 2001). Kolb posits that experiential learning theory integrates learning, work, and other life activities, alongside the creation of knowledge itself. On one hand, it addresses the demands of the labour market, while on the other, it allows students to engage in real-world tasks within the classroom. The author presents a learning model consisting of a four-stage cycle: concrete experience (participation in an activity), observations and reflections (reflection on the experience), abstract conceptualization (extraction of concepts and principles), and active experimentation (application of learning in new situations) (Kolb, 1984).

Some innovative techniques for implementing experiential learning include project-based learning or service learning. Project-based learning is grounded in addressing real-world problems, where students work in teams to tackle them, for instance through simulations and role-playing games. These enable students to experience real-world situations in a safe and controlled environment, aiding in the development of practical skills and informed decision-making.

Experiential learning provides students essential skills for both academic success and professional life. Additionally, socio-emotional, ethical, collaborative, communication, creativity, critical thinking, empathy, and citizenship competencies are developed (Gleason Rodriguez & Rubio, 2020).

3. Decarbonization plan at university

To actively engage in sustainability promotion, the European University of Valencia (UEV) has formulated a Decarbonization Plan. The initiative is devised to diminish the campus carbon footprint through active involvement of students and businesses in the academic year 2023-2024. Specifically, the plan includes among other actions, the challenge of decarbonizing one of the buildings located at General Elio Street, also called Viveros building, which serves as the focal point of this article.

During two consecutive days, two complementary activities were carried out. The inaugural day features a masterclass facilitated by the university's environmental department, in collaboration with notable enterprises from the Valencian Community (Ikea, Sodexo, and Imedes). This session aimed to show students on the significance of carbon footprint reduction and provide them with practical strategies to implement at the organizational level. On the second day, students engaged in a challenge solving event, facilitated by expert

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

corporate mentors, where they collaboratively addressed different specific challenges (energy, water, waste and transport) aimed at campus decarbonisation. By actively involving themselves in addressing specific sustainability challenges within the university, students assumed accountability for the solutions they propose.

Participation was opened to students across diverse disciplines at the UEV, encompassing fields such as Business Administration, Marketing, Data Science, Physics, and Industrial Management Engineering. Indeed, teams were carefully created to include different student's profile and simulate real professional context.

In the forthcoming academic years, the Decarbonisation plan is set to expand to include a larger number of buildings within the UEV. This includes a continuous study to monitor the progression of the carbon footprint in subsequent academic years, derived from the student's solutions.

4. Methodology and data collection

The methodology is based in participants observation (Corbetta, 2003). A mixed-methods approach has been adopted to assess the efficacy of the intervention, including quantitative and qualitative assessment (Creswell, 2009). This includes pre-session questionnaires to estimate participants' baseline knowledge on sustainability, followed by post-session questionnaires to evaluate their progression and level of personal commitment with sustainability issues. Concurrently, interviews with collaborating companies were done to compile insights on the initiative's outcomes. These methods collectively aimed at measuring the real involvement of young university students in sustainability.

Both questionnaires, the one before and the one after the events, have in common the evaluation of basic knowledge about sustainability and carbon footprint. Specifically, the distribution of questions according to the type of basic knowledge in each specific topic is: sustainability and climate change (questions 1 and 2), carbon footprint (3 – 5), reduction of carbon footprint in energy (6), transportation (7), waste (8) and water consumption (9). In addition, the last questions (10, 11, and 12) aim at assessing, in the pre-events questionnaire, the importance that students give to sustainability and their previous contact with other sustainability related activities. In the post-events questionnaire, the last questions (10, 11 and 12) pretend to measure the students' perception of what they have learned and their awareness and commitment to environmental issues resulting from the experiential event.

Regarding the interviews to the companies, they were addressed to evaluate the added value that the companies would bring to the outcomes of this experience. Thus, their views on the need to include sustainability issues in university non-academic activities were considered, as well as their concern and involvement of students in the challenges presented. Likewise, questions aimed at assessing how the experience provided by professionals, derived from

BY-NC-SA 2024, Editorial Universitat Politècnica de València

their trajectory in their field, had influenced the activity, analysing the type of feedback they provided to the students. Regarding the challenges, the goal was to understand the companies' insights on the potential of the solutions proposed by the students, as well as to compare them with current market trends, their level of application in their own companies, and the degree of generation of innovative ideas. Finally, they were asked about their perception of the degree of networking among students (employment opportunities) and teachers, as well as future collaboration between the company and the university.

5. Results and discussion

5.1 Pre-experience analysis

As mentioned in the methodological section, a questionnaire was conducted on 25 participants prior to the challenge solving event with the aim of obtaining both quantitative and qualitative assessments of the knowledge and awareness our students possess, and how attuned they were to this topic.

About the sustainable development, the responses indicate a varied understanding of what sustainable development means, with the majority identifying it as meeting present needs without compromising the future or the environment. Additionally, a large majority (92%) identifies the cause of climate change as human-made, mainly due to industry and transport. This implies that the students are well-informed about the human role in climate change.

Moreover, an overwhelming majority (92%) correctly recognizes the carbon footprint as the total emissions of greenhouse gases released by activities. This reflects a high level of knowledge about the concept of carbon footprint, and the majority (96%) are aware of taking some action and being more proactive with the aim of reducing their own carbon footprint, including the use of recycled products and the promotion of sustainable forestry practices. Although opinions vary on the most effective ways to decrease the carbon footprint from transportation, there is a mild favouritism towards encouraging the adoption of low-emission vehicles and carpooling. Meanwhile, there is a robust agreement on the importance of recycling and reuse strategies in lowering waste production and an organization's carbon footprint. Additionally, using water reuse systems has proven to be an efficient method for reducing the carbon footprint associated with water use.

Last, there is significant prior participation in sustainability-related activities, with 40% indicating they have not participated and 60% indicating they have. Among the activities developed by our students we can find: domotize light systems, clean some beaches, clean green areas, attend conferences, talks and seminars on the subject, among others.

In summary, these results reflect a high degree of awareness and knowledge about sustainability, causes of climate change, carbon footprint, and actions for reduction. Before

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

the event our students recognize the importance of these issues, and many are already taking action or are willing to do so. This suggests that initiatives like challenge solving educational events may be having a positive impact on understanding and commitment to sustainability.

5.2 Post- experience analysis

Results of the questionnaire taken by students after the challenge solving event, show on the one hand, that 52.2% defines sustainable development as economically viable, socially fair, and environmentally compatible development. This reflects a shift towards a more comprehensive definition of sustainable development that encompasses multiple dimensions. Also, most of them (82.6%) continues to recognize climate change as being caused by human-generated carbon dioxide emissions. However, an additional small percentage now identifies other factors, which may indicate a more nuanced understanding. An elevated percentage (65.2%) understand that the purpose of calculating the carbon footprint is to identify areas to reduce greenhouse gas emissions, while others recognize the importance of measuring an organization's specific impact.

The vast majority (82.6%) correctly understand that carbon neutrality involves offsetting carbon emissions with actions that reduce or absorb them, reflecting an understanding of the importance of compensatory actions. The overwhelming majority (91.3%) is also agreeing that implementing energy efficiency measures and using renewable energy are the most effective actions within an organization, while a significant majority (56.5%) believes that establishing a teleworking policy is the most effective strategy to reduce the carbon footprint of employee transportation, indicating an acknowledgment of modern work practices as an important factor.

A high percentage (87%) suggests that implementing waste reduction policies and the use of reusable packaging is a key specific action to reduce waste generation. Similarly, 87% think that implementing dual-flush systems in toilets is an effective action, demonstrating awareness of efficient water consumption practices. More than half (60.9%) feel they have learned a lot about carbon footprint in businesses and decarbonization, indicating that the event was effective in increasing knowledge.

On the other hand, nearly 39.1% indicate that the event significantly impacted their perception of the importance of sustainability and carbon emission reduction, with many motivated to take concrete actions.

These results show an increase in understanding and commitment to sustainability and decarbonization practices. They reflect the event's success in enhancing knowledge and inspiring participants to adopt significant measures towards sustainability.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

5.3 The perception of the challenge solving experience of the companies.

All participating company mentors highlighted the critical importance of interdisciplinary teamwork at the event as key to fostering innovative, useful, and applicable solutions in a real world environment. This approach enhances collaboration and expands learning opportunities, making it essential for developing valuable strategies for nowadays challenges. Additionally, 50% recognized the value of working in a simulated real life environment as a valuable hands-on experience.

Half of the businesses involved recognized market opportunities from the challenge experience trends, seeing relevance in the student-generated ideas. Additionally, a significant 75% believe these solutions could effectively tackle decarbonization challenges, highlighting the proposals' practicality and potential impact. However, only the 50% of them, believed that the collaboration between their company and the students generated innovative ideas. This may imply that while some collaborations were successful in generating new ideas, others may need better focus or structure. Nevertheless, 75% of the companies claim to have established significant connections with the university and students that could translate into future collaboration or employment opportunities, which is indicative of the challenge event success in creating valuable professional networks and possibly identifying emerging talent.

There is an interesting point to highlight which is a real interest from the businesses in continuing collaboration with the university. These results, illustrate a positive impact of this experience in university students, in terms of both professional development and the creation of partnerships between academia and industry.

The participating companies recognized various benefits, from the generation of innovative ideas to the formation of meaningful connections that could foster future collaborations and business opportunities.

6. Conclusions

The pre-experience analysis indicated that students were already highly aware of sustainability issues, with many actively engaged in related activities. Combining this existing awareness with the challenge experience appears to have further enhanced their understanding of and commitment to sustainability for decarbonization efforts. The results of the study highlight how incorporating experiential learning into university curricula strengthens the connection between theory and practice. Through this project, students not only gain theoretical knowledge about sustainability, but also actively participate in implementing real solutions on campus, resulting in deeper and more engaged learning.

2024, Editorial Universitat Politècnica de València BY-NC-SA

The evolution in the students' conceptualization of sustainable development following the event reflected a continued recognition of the human impact on climate change and a deep understanding of carbon footprint management. Notably, their knowledge extended into actionable insights, such as the importance of energy efficiency, waste reduction, and water conservation practices, all essential for a sustainable future.

The approach also incorporates strong collaboration with external companies and organizations, enriching the educational experience by providing students with an environment that simulates real professional challenges. This not only better prepares students for the job market, but also enables them to apply their knowledge in practical scenarios that require innovative and sustainable solutions. Transdisciplinary is central to our program, integrating knowledge from business, science, engineering, design, and law to address the complexity of sustainability challenges. This integration promotes a more holistic and effective understanding of the issues, preparing students to work in multidisciplinary teams and adapt to diverse real world situations and demands. From the corporate perspective, the event served as a platform for active mentoring, interdisciplinary collaboration and real world problem solving, culminating in innovative solutions that may be aligned with market trends. While not all collaborations resulted in revolutionary ideas, the event was successful in creating valuable professional connections and identifying promising talent. Mentor companies expressed genuine interest in maintaining their collaboration with the university, underscoring the mutual benefits of such partnerships.

In conclusion, the challenge learning experience part of the Decarbonization Plan was much more than an academic exercise; it acted as catalysts for tangible change, equipping students with the tools needed to tackle real world sustainability challenges and enabling the university to tap into fresh and innovative perspectives. Initiatives like this provide forge pathways for future business opportunities and professional development. This event has effectively demonstrated that when academia and industry converge on common ground, the potential for progress is immense.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Corbetta, P. (2003), Social Research: Theory, Methods and Techniques, London, doi: 10.4135/9781849209922.

Coya, M. (2001). La Ambientalización de la Universidad. Tesis doctoral, Universidad de Santiago de Compostela. España.

Creswell, J.W. (2009), Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 3rd Ed., SAGE Publications.

Escolano, A. F., Rodríguez, J. R., García-Grau, E., García, C. S., López, A. B., Fort, G. B. & Canut, T. L. (2016). Utilidad diferencial de dos métodos de aprendizaje experiencial en el entrenamiento de habilidades psicoterapéuticas. Revista del Congrés, Internacional de Docència Universitària i Innovació (CIDUI), (3), pp. 2-12.

García, M.L. & Vergara, J.M.R. (2000). La evolución del concepto de sostenibilidad y su introducción en la enseñanza. *Enseñanza de las ciencias: revista de investigación y experiencias didácticas,* pp. 473-486.

Gleason Rodriguez, M., & Rubio, J. (2020). Implementación del aprendizaje experiencial en la universidad, sus beneficios en el alumnado y el rol docente. *Revista Educación, 2020,* 44(2). https://doi.org/10.15517/revedu.v44i2.40197

Kolb, D.A. (1984). *Experiential Learning. Experience as The Source of Learning and Development*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Krzyzaniak, S., Messman, A., Robinson, D.W., Schnapp, B., Li-Sauerwine, Gottlieb, M. & Man-Yee Chan, T. (2022). *Education Theory Made Practical: Volume 4*. McMaster Office of Continuing Professional Development, Hamilton, ON, Canada.

Luna, S. A. & Valdés, L. (2017). ¿Cómo aprendemos de los referentes visuales en el Diseño? Aproximación desde la teoría del aprendizaje experiencial de Kolb. A3manos-Revista de la Universidad Cubana de Diseño, 4(6), pp. 27-34.

Romero, M. (2010). El aprendizaje experiencial y las nuevas demandas formativas. Revista de antropología experiencia, (10), pp. 89-102.

Smith, M.K. (2001). David A. Kolb on experiental learning. *The encyclopedia of pedagogy and informal education.* https://infed.org/david-a-kolb-on-experiential-learning/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Llars Application: Changing Lives From Download To Download

Alba Álvarez Tormos [a], Joan Aparicio Navarro [a], Stella Bayona Sedeño [a], Cristina Catalán Lario [a], Jesús Comos García [a], José Manuel Gómez Maestre [a], Madalina Ionela Grigore [a], Érica-Alejandra Ivars Bernabeu [a], Santiago Guillermo Martínez Lozano [a], Rubén Merino Cantos [a], Lucia Monzón Barquero [a], Adriana Moreno González [a], Javier Navarro Bellver [a], Luisa Fernanda Robayo Julio [a], Iris Sánchez Orts [a], Marcel Sanz Serra [a], Alba Soler Espí [a] and Silvia Aja Martínez [a]

[a] CIPFP Blasco Ibañez, Quimica y Salud Ambiental, Valencia, España.

Abstract

The purpose of this paper is to explain a new teaching experience implemented in Vocational Education and Training. To increase the engagement of our students and achieve a more significative learning, the students of CIPFP Vicente Blasco Ibáñez were suggested to develop a smartphone app. The proposal focuses on the development of a revolutionary mobile application aimed at addressing environmental challenges in urban environments. The app's main objective is to raise public awareness of the risks associated with light, noise, air and waste pollution, transforming information into practical knowledge and concrete actions.

Through an intuitive interface and interactive tools, our app will provide real-time data on the local environmental situation, allowing users to clearly understand the impacts of these forms of pollution on their daily lives, in addition to considering the Sustainable Development Goals (SDGs).

In conclusion, a new methodology was developed to increase the interest of students in the subject with the aim of increasing their motivation to learn. Indicators should be implemented in the future to measure the impact of this new approach both on academic performance and student motivation. Moreover, this methodology could be improved by collaborating with other vocational education institutions that could work with our students to develop the designed application.

Keywords: interface; app; environmental situation; Sustainable Development Goals.

How to cite: Álvarez Tormos, A.; Aparicio Navarro, J.; Bayona Sedeño, S.; Catalán Lario,C.; Comos García,J.; Gómez Maestre, J.M.; Grigore,M.I.; Ivars Bernabeu, E.A.; Martínez Lozano, S. G.; Merino Cantos, R.; Monzón Barquero, L.; Moreno González,A.; Navarro Bellver, J.; Robayo Julio,L.F.; Sánchez Orts, I.; Sanz Serra, M.; Soler Espí, A. and Aja Martínez,S. (2024) Llars application: changing lives from download to download. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 561-569. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – LLARS application



Source: Prepared by the Group

1.Introduction

New and innovative teaching models focus on active learning methodologies that help students achieve a significative learning and increase their motivation in class.

The development of digital technology has revolutionized every aspect of our daily lives and, of course, the educational field. Technology opens new avenues and tools to support teaching work, and in this article, we present a sample of some innovative educational experiences that make use of digital technology in order to improve the learning process.

The use of Apps for any activity we carry out throughout the day has become essential. A very enriching experience for our students is the development of apps with a social commitment.

This method combines the processes of learning with the development of projects aimed at covering needs detected in a local or global context. The educational experience that we suggest is based on the development of ApS through the creation of an application for mobile devices. This article focuses on a new teaching experience implemented in CIFP Vicente Blasco Ibáñez in which the students were suggested to design a mobile application for environmental management purposes.

Nowadays, pollution is a serious problem in many cities from humans to biodiversity. Therefore, we must inform people about how pollution affects us and how important it is to implement preventive measures to mitigate this risk; we also want to make users aware of the importance of the SDGs to encourage activities that influence the support and improvement of the environment.

Our project aims to provide useful information, easily and conveniently accessible to the user on the current state of the environmental situation in their city, for which we will translate the parameters in simple language, so that the user will be aware of the real risks to which he is exposed and thus raising awareness of the real danger of pollution in their city. This project would be a great innovation, as there is currently no platform that collects all the information concerning pollution in detail and that is available to any citizen on the same platform; in addition this application would provide the ability to compare these data between different sectors or even the entire city, thus promoting awareness about the environment and to understand the risk we are subjected to.

2024, Editorial Universitat Politècnica de València BY-NC-SA

We have opted for the development of a custom software in the form of mobile application, since today the mobile Apps have positioned themselves as one of the most effective tools and mass use for the transmission of information, taking into account the adaptability and orientation towards the provision of environmental information, where the user can view clearly and in real time the environmental parameters of their locality.

The main objective is to raise awareness and improve the population's perception of the risks associated with light, noise and air pollution and waste management through a mobile application, which will focus on providing accessible, understandable and visually attractive information to the user, allowing a better understanding of the impacts of these forms of pollution in their environment. However, we cannot offer specific data because it's the first time that this methodology has been used in our institution. Therefore, we do not have enough data to support the claim with figures. The subjective impression of the teachers was that students were more engaged by this approach. Some indicators should be defined to describe the impact of this new teaching model. Regarding this, indicators of academic performance and results of surveys should be implemented.

Fig. 2 – LLARS application



Source: Prepared by the Group

2. Topic of interest

Our article focuses on a good practice developed in CIPFP Vicente Blasco Ibáñez to implement an active learning methodology. The smartphone app development was used as a "learning by doing" strategy to achieve the goals of the subject. This good practice is related to:

- Competency-based learning and skill assessment,
- Innovative materials and new tools for teaching
- Teaching and learning experiences,
- Educational Technology
- Emerging technologies in learning,
- New teaching/learning theories and models

3. Teaching methodology

It is important to analyze several elements of the group of students to decide how to structure the project. The aspects to be considered, among others, are the cohesion of the group to achieve the proposed objectives. Another important element is the size of the group, because it can lead to more methodological difficulties in its development. In addition, homogeneity

BY-NC-SA 2024, Editorial Universitat Politècnica de València

plays an important role, that is why the organization of the work in small groups formed freely by the students can be of great help in eliminating the difficulties that an individualized teaching approach may entail.

The group was further subdivided into subgroups of work areas. These were freely chosen according to the topic to be worked on in each one. Four groups of four students and one group of five students were formed. Our group was made up of 17 students who were divided into 5 working groups. Each subgroup was assigned a theme and some items to develop. The pedagogical model applied is cooperative learning, which is based on the following principles of mutual help among classmates, thus promoting the inclusion of all students in the same class group.

Cooperative learning seeks at all times that students learn from their peers. But cooperative learning also wants to be a pedagogical model that gives priority to inclusion and in which it is intended that all students start with the same possibilities, that all students feel that they are part of a gear and that they are a fundamental piece. In our case, the students worked cooperatively, respecting the established dates.

When all the subgroups had their section completed, the subgroups were distributed, creating new ones, depending on the themes: design, social networks, logo, formal aspects. Finally, it was possible to coordinate all of them and as a result we have the present project.

Innovation is measured using key performance indicators, that allows measuring characteristics, behaviors and phenomena throughout the learning process. In the future, indicators should be implemented to measure the impact of this new methodology. We suggest the use of indicators before and after the development of the final work, like surveys about satisfaction with the results obtained, satisfaction with the group work, the level of learning and learning results. This will provide important information about how students felt during the learning experience.

To measure academic performance, we suggest calculating the average mark of three academic years before and after this methodology was implemented. This will provide important information about the impact of this project in the marks of our students.

4. APP Components

Our proposal consists of the development of an application that allows users to easily access relevant information about pollution in the city. The aim is to achieve that this information can be accessed easily by anyone. We have chosen the creation of an application, since today anyone has easy access to the internet and/or a mobile device such as laptops and cell phones, so this would be a very convenient and relatively simple way to disseminate this information we want to convey to the population and to be accessible for anyone. Since the students

2024, Editorial Universitat Politècnica de València BY-NC-SA

designed the app features but didn't develop it, collaboration with IT schools is advice for this next step in the project.

Fig. 3 – LLARS application



Source: Prepared by the Group

4.1 Atmospheric pollution

The main causes of atmospheric pollution originate from human activities. However, this does not mean that there are no sources of pollution from natural processes. With the Industrial Revolution, during the second half of the 18th century, the rise of factory production began, the development and increasing use of means of transportation and, therefore, the increased use of fossil fuels. As a result, there was an increase in the concentration of gases such as carbon dioxide, nitrogen oxide or sulphur oxide, all of which are very harmful to health in high quantities.

4.2 Acoustic contamination

The World Health Organization (WHO) defines as NOISE any sound above 65 decibels (dB). Specifically, such noise becomes harmful if it exceeds 75 dB and painful from 120 db. Consequently, this organization recommends not exceeding 65 dB during the day and indicates that for a good night's sleep, ambient noise at night should not exceed 30 dB.

Excessive and constant noise, beyond the logical negative effects on hearing, can cause other problems to human health.

4.3 Light contamination

We can define light contamination as the increase in the background brightness of the natural night sky, due to the reflection of light from artificial illumination. This increase in artificial light disturbs and alters the properties of the receiving medium. This type of pollution is due to artificial light being directed skyward such as poorly designed streetlights, excessive power in artificial lights or inefficient artificial lighting schedules.

This excess of light not only disturbs the darkness of the night, but also has consequences for the environment, astronomy and our health.

4.4 Waste management

Waste management involves different activities that are necessary to deal with this important problem. There are 3 main phases of waste management like recovering and collecting waste:

BY-NC-SA 2024, Editorial Universitat Politècnica de València

for this, containers are used in which waste must be deposited, transporting the waste: in this phase the waste is transported in trucks to the sorting, or waste treatment: in this last phase of waste management, waste undergoes different treatments depending on its origin using different techniques.

5. How will the application work?

5.1 Waste finder, from words or images, for its correct recycling or disposal

It has happened to all of us to have waste in hand and not know where we should deposit it. With our application we want to facilitate the work of recycling with a search engine that would help the user search by images or keywords which is the container to which the waste belongs. According to the characteristics derived from the image or word entered, the search engine will classify your waste into plastic, paper and cardboard, glass, organic, battery containers, medicine containers, textile containers, oil containers or eco-parks.

5.2 Map of containers, recycling sites, ecoparks and scrapyards

Don't know where your nearest container is? Do you want to know more about the area where you live? From our APP we provide access to information on the location and distribution of the different containers through a map with layers, indicating the place where each container is located, dividing them according to the type of waste they belong to and according to the selected area. Not only will the use of the map allow us to know the exact location of the containers, but we can also locate ecoparks in the selected area that interests us. And if you wonder why you want to know where an ecopark is located, let me tell you that the ecopark is a place where the whole family enjoys and learns about the conservation of biodiversity and natural environments, through educational and recreational experiences.

5.3 Container filling capacity indicator

By means of sensors placed in the containers, the user will be informed about the percentage of available capacity of these, to advance in the intelligent management of solid waste in the city. Thanks to the data provided by our application, the citizens of the selected area interested in a particular container will be able to know the exact occupied capacity in which the deposit is located. The section of our application related to the sensors will consist of the user observing a map in which he will be able to select the container he is interested in, and the application will show him a percentage that will indicate the available capacity inside the container.

The application will help the user to know whether it is advisable or not to throw the waste in that container, showing in a small section the filling percentages. On the same map, selecting each container will show an indication of the approximate date and time of collection. Also,

2024, Editorial Universitat Politècnica de València BY-NC-SA

another screen will open with the collection time of the different types of containers in the public space, such as paper, waste and glass, in each area.

This will allow users to know when they will be able to throw away their waste in case the container is full. In the application, within the map section, people with reduced mobility (PRM) will be informed where the adapted containers or islands are located, to facilitate accessibility to these people and their collection.

6. Conclusion

Our group consider it essential to be able to address the new educational realities that change so quickly. A way to do it is designing apps Llars, that can help improve teaching methods on your own terms.

We must consider that the key to achieving success is having the right tools with which to explore current technologies and develop the skills necessary to innovate. By strategically implementing tools like Llars Apps, they can be created to meet unique needs, giving students a full-quality experience.

The biggest challenge would be to collaborate with other vocational education institutions of to be able to create the LLARS application and test it. Our students would design the features of the app, while IT students would create the app, because the application is a pilot test, so there has been no opportunity to interact with the real world, which we can affirm that the data used by the application is real, taken from official pages and users can enjoy the required data related to the environment in real time.

6.1 Conclusions reached by students during app development

We can conclude that the development of this proposal would be very positive for society. The reasons are because this application is easily accessible to all audiences, most of the population uses a cell phone, or a computer connected to the Internet in their daily lives and the designed application shows a high transparency to the population and provides detailed and easy to understand information to the user.

In addition, it should be noted that this proposal is very innovative, as it includes a lot of information for users in terms of waste and its management in the city. It is also very innovative the possibility of monitoring the containers through sensors placed inside of them, as they will inform users about the available capacity of these, to advance in the intelligent management of solid waste in the city, betting on innovation and technology.

The following links lead to the website and Instagram profile that the students developed for this project: https://empresallars.wixsite.com/my-site-1

https://www.instagram.com/p/CooYrg3LLpW/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

6.2 Conclusions reached by teachers from the teaching and learning experience

Teachers involved in this experience had the impression that this new methodology was more motivating for students than traditional approaches applied in the past. Nevertheless, this subjective impression should be confirmed by indicators in the future. In this article, indicators were suggested to measure both student satisfaction and academic performance. In addition, this project could be improved in the future by collaborating with other vocational education institutions that could work with our students to develop and implement the designed application. We cannot offer concrete examples because it is a pilot test. The next step, if it had continuity, would be to create the application.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Google. (2022, julio 12). Página principal [Sitio web]. Recuperado de https://www.google.com

Ministerio para la Transición Ecológica. Página principal. Recuperado de https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/atmosfera-y-calidad-del-aire/contaminac ion-acustica.html

Iberdrola. Página principal. Recuperado de https://www.iberdrola.com/sostenibilidad/que-es-contaminacion-acustica-causas-efectos-soluciones

B.O.E. Página principal. Recuperado de https://www.boe.es/buscar/act.php?id=BOE-A-2003-613

Naciones Unidas. Página principal. Recuperado de https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/

Ayuntamiento de Valencia. Página principal. Recuperado de https://www.valencia.es/es/cas/calidadaire/mapa-del-ruido

Conselleria de Medio Ambiente, Aigua, Infraestructura y Territorio. Página principal. Recuperado de https://mediambient.gva.es/documents/20549779/161483924/Actualizaci%C3%B3n+Plan+L%27Horta/c8f8e 278-f669-40bc-bbdb-cdc440c4b460

B.O.E. Página principal. Recuperado de https://www.boe.es/buscar/pdf/2011/BOE-A-2011-1645-consolidado.pdf

O.M.S. Página principal. Recuperado de https://www.who.int/publications/i/item/9789240034228

Ministerio de Agricultura, Pesca y Alimentacion. Página principal. Recuperado de https://sig.mapama.gob.es/geoportal/geoportal.html

2024, Editorial Universitat Politècnica de València BY-NC-SA

B.A. Página principal. Recuperado de https://buenosaires.gob.ar/ecoparque/que-es-el-ecoparque#:~:text=El%20Ecoparque%20invita%20a%20toda,de%20experiencias%20educativas%20y%20recreativas.

Valencia Plaza (2019). Página principal. Recuperado de https://valenciaplaza.com/llegan-los-contenedores-inteligentes-a-valencia

Ayuntamiento de Valencia. Página principal. Recuperado de https://geoportal.valencia.es//home/?lang=1

Contaminación del aire de CEA. (2023). Página principal. Recuperado de https://aqicn.org/city/spain/valencia/sagunt/cea/es/

Pixabay. Página principal. Recuperado de https://pixabay.com/es/

B.O.E. (2002). Ley 7/2002, de 3 de diciembre, de protección contra la contaminación acústica.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Learning Cooperations as a Method to integrate Education for Sustainable Development into Further Vocational Education

Thomas Spelten[a], Désirée Rottmann[a] and Semih Severengiz[a]

[a]Bochum University of Applied Sciences, Germany

Abstract

Education for Sustainable Development (ESD) and vocational education and training (VET) play a vital role in sustainability and battling climate change. We present a framework on how to combine ESD into further VET in the form of learning cooperations with students studying sustainability related programmes. This framework is carried out and evaluated in the context of the research project 'UpTrain' which develops further VET for the public transport sector. There are two further VET programmes on two different educational levels being developed that incorporate learning cooperations. These learning cooperations are then broken down into the used methods as well as the ESD related skills that are taught with these methods. They are evaluated by the participating teachers, students and participants of further VET. The results show that the learning cooperations receive mixed reviews where participants of the higher level programme view them more positively than those partaking in the other programme. Due to the small scale of this study, further research still needs to be done on this topic to support these findings.

Keywords: Vocational Education and Training; Education for Sustainable Development; learning cooperation.

How to cite: Spelten, T.; Rottmann, D. and Severengiz, S. (2024) Learning Cooperations as a Method to integrate Education for Sustainable Development into Fur-ther Vocational Education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 570-579.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The field of sustainability is an emerging and important topic. Finding interdisciplinary strategies to mitigate and adapt to climate change and to shift our way of working and living towards sustainability are crucial goals of our society. The UNESCO recognises the important role of education in this through the introduction of the concept of Education for Sustainable Development (ESD), which aims to convoy not only specialist knowledge but also skills, attitude and values (UNECE - Committee on Environmental Policy, 2005). Furthermore to support the green transition, vocational education and training (VET) is needed (European Commission, Directorate General for Employment, Social Affairs and Inclusion, 2021). However, the field of VET is still lacking a strong incorporation of ESD. Especially in jobs which are not sustainability related, there is no systematic integration of ESD in education (Holst, 2022). The need for more ESD as well as better VET ties strongly into the United Nations Sustainable Development Goal 4. This holds especially true for the subgoals 4.3 (ensure access to quality technical, vocational and tertiary education) as well as for 4.7 (ensure that all learners acquire the knowledge and skills needed to promote sustainable development).

In VET there are many approaches to combine VET with academic higher education, such as the German dual system. This system combines the benefits of the theoretical approach of universities with the hands-on experience of VET to better qualify people for future jobs. Learning cooperations are already a part of this system (Langfeldt, 2018). Learning cooperations are not clearly defined in the literature and can be understood to mean learning at different learning venues such as vocational schools and different industrial companies or to combine different learning groups such as students at universities and students from vocational schools. This dual system however mostly focus on universities and vocational schools. The benefit of the combination of these systems should be also applicable to further VET. This combination would then allow for the integration of ESD which requires lifelong learning. We will thus focus on this case of a learning cooperation and define a learning cooperation to be the combination of two groups with different educational background working and learning together.

In this paper we develop and implement frameworks for such learning cooperations with students studying sustainability related programmes to incorporate this combination of ESD and VET. These learning cooperations are carried out in the research project 'UpTrain' (2020-2024). It is made up of four universities, four public transport companies and the Academy of the Association of German Public Transport Companies. This project aims to develop two new training programmes for the mobility sector to prepare the participants for future challenges of the sector and to enable future-orientated specialized careers. We match the used methods and taught subjects in the learning cooperations to relevant ESD competences

BY-NC-SA 2024, Editorial Universitat Politècnica de València

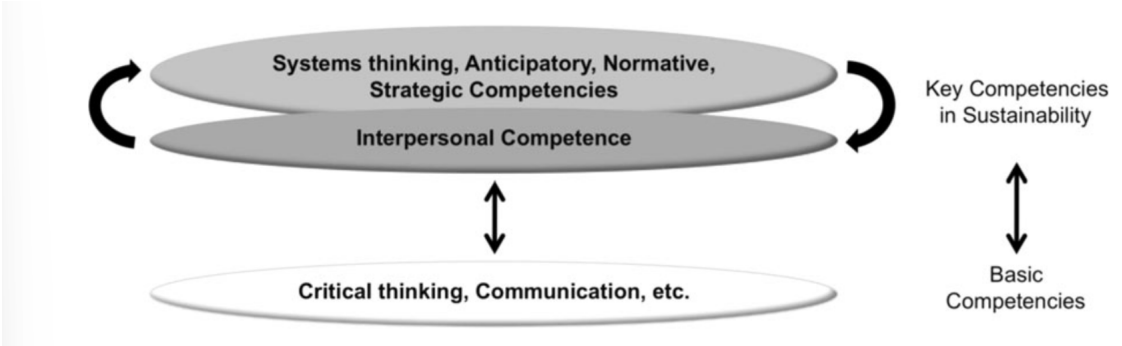
which we develop according to Wiek 2016. We also present evaluations of these learning co-operations which were done in the context of the research project.

2. Theoretical Background

ESD is understood as an educational approach in order to convoy competencies for sustainable development and transformation (Rieckmann, 2016). The overall goal is to live common values such as "*solidarity, equality and mutual respect between people, countries and generations*" (UNECE - Committee on Environmental Policy, 2005). In the approach of lifelong learning, all age groups regardless of the educational background can be taught according to the ESD methodologies (UNECE - Committee on Environmental Policy, 2005).

In literature, this method has two basic strands. As these strands are subject to two different basic assumptions on behaviour for sustainable development, the main distinguishing features lie in the type of competencies to be taught. ESD type 1 assumes that a certain set of values and attitudes lead to appropriate human behaviour and ultimately to sustainable development (Rieckmann, 2016; Vare & Scott, 2007). Hence, accordingly to ESD type 1, it is concluded that the values and behaviors must be specifically promoted in order to achieve sustainable behavior among people. This can be e.g. incentives and rewards to consciously learn and increase the attractiveness of methods for sustainable behaviour. ESD type 2 assumes a *dynamic* development process of values and attitudes according to the changing demands of the environment for sustainable development (Vare & Scott, 2007). In this paper, the idea of ESD type 2 has been applied for the learning cooperations. Accordingly, the applied ESD methods followed the goal to enable the participants and students for critical thinking and solution oriented problem solving (Wiek, 2016). Scientist have not yet agreed on a general set of competencies that is needed. Fig. 1 shows the differentiation in the key competencies in sustainability, interpersonal and basic competencies (Wiek, 2011).

Fig. 1–A layered set of competences in academic sustainability education



Source: Wiek (2011)

The number and type of competencies taught differ according to the level and organization of education. According to Wiek, people with particularly high degrees should master several

 BY-NC-SA

competencies (Wiek, 2011). The key competencies described in a reference framework for academic program development by Wiek 2011 and 2016 constitute the learning objectives for the teaching units in this study. This is understood as an approach to convey the following key sustainability competencies in this study: future thinking (or anticipatory), collaboration (or interpersonal), system thinking competence, strategic thinking (or action-oriented) competence. *Future Thinking* describes the ability to analyse, understand and evaluate future related sustainability matters. Students can describe with different types of data possible future scenarios. *System Thinking* qualifies students to investigate complex systems with multiple themes. This means that they gain the ability to analyse different types of data applying different methods. The *Strategic Thinking Competence* (Wiek, 2011) enables students to develop and conduct transformative sustainable development strategies and frameworks (Wiek, 2011, p. 9). This set of skills includes concepts such as design and planning to governance and change as well as decision making (Wiek, 2016). *Collaboration* (Wiek et al., 2011) & *Interpersonal Competence* (Wiek, 2011) is a communication ability to collaborate, participate, negotiate and develop leadership skills (Wiek, 2016).

3. Methodology

The learning cooperations take place in the research project 'UpTrain'. During this project, there are two VET programmes being developed for further education. Firstly, the Certified Occupational Specialist for Electronics Mobility (BS) at the German 'Fortbildungsstufe' (Advanced training level) 1 is just below the level of complexity of a bachelor's degree. Secondly, the Master Professional in Technological Innovation Strategies Mobility (TIM) at the German 'Fortbildungsstufe' 3 is comparable to the complexity of a master's degree (Bundesinstitut für Berufsbildung, 2024). The programme BS contains 400h over the span of 8 months and is held twice over the course of the project. These two iterations will be called BS1 and BS2. The participants of this programme are people with a background in electronics or mechatronics with no academic background. The programme TIM contains 1600h over the span of 16 months and is held once over the course of the project. The participants of this programme have leading rolls in their company varying from head of workshops or planning roles to project management and corporate development. These participants also have no academic background. During the learning cooperations, students of Bochum University of Applied Sciences (BUAS) enrolled in the study programmes *applied sustainability* or *sustainable development* joined them.

In the BS programme, two iterations of the same learning cooperation consisting of two full days were carried out at BUAS. The subject of both was connected mobility as part of the solution for more sustainable mobility. The first iteration consisted of 21 participants and 5 students, with the students only joining on the second day. The second iteration featured a revised concept and consisted also of two days with 20 participants and 5 students, but the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

students only joined for half a day. The methods used in both days as well as their connection to ESD can be found in Table 1.

Table 1 – Methods used and ESD competencies taught in connected mobility learning cooperation

Method	Subject example	Corresponding ESD competencies	Students present
Bar camp	Discussion of current/future technologies (Autonomous driving, Car sharing,...)	Preparation for Future Thinking skill	No
Frontal lecture	Climate change, financing of public transport, sharing services	-	No
Group session	Development of new connected mobility concept for existing real-world problem	Collaboration Competence, Future Thinking Competence	Yes
Jigsaw/Group puzzle	Presentation/Discussion of developed concept	Collaboration Competence	Yes

Source: Own elaboration

The detailed concept for both of these learning cooperations can be found on the SEED platform (*SEED Online Platform*, 2024).

During the first iteration of BS, three main evaluations were carried out, roughly every three months. The participants were given digital questionnaires which were anonymous and non-obligatory. Only the last one which was open from May to June 2023 included the learning cooperations as they had had none until then. In this final evaluation, a total of 6 participants participated. To supplement this, feedback was gathered after the learning cooperations, from participants, students and teachers in an open non-formal conversation in the open classroom. The second iteration is evaluated in the same way, with evaluations concerning learning cooperations being open from February to March 2024. There were further evaluations done after every week which were significantly shorter and mostly contained free text feedback. Additional evaluations were done through personal conversations which are not considered in this study.

In the TIM programme, two learning cooperations were carried out at BUAS. The first one was on the subject of scenario development and scenario software. Scenario development is part of sustainable education to evaluate current and future development under sustainability aspects. The second one was on ecodesign to enable more sustainable design of a product. The learning cooperation about scenario development consisted of a two-hour online meeting as preparation and 3 full days (8 hours) and half a day (4 hours) of present learning. These days were split into 1,5 days in one week and 2 consecutive days a month later. Here on average of 7 participants were present while 6 students joined for the afternoon of the first day. The methods used in this learning cooperations are listed in Table 2.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Table 2 Methods used and ESD competencies taught in scenario development learning cooperation

Method	Subject example	Corresponding ESD Competencies	Students present
Frontal lecture	Explanation of methodological procedure	-	Yes
Group session and guided group discussion	Development of influence factors for future mobility and sustainability	Future Thinking	Yes
Individual and group assignments	Researching trend-breaking events	System thinking competence	No
Case study	Example of scenario study and their impact	Future Thinking	No
Experiential project work	Developing own scenario studies	Future Thinking	Yes

Source: Own elaboration

The learning cooperation about ecodesign consisted of one day with 6 participants and 6 students, with students being present for half a day. The methods used are listed in Table 3.

Table 3 Methods used and ESD competencies taught in ecodesign learning cooperation

Method	Subject example	Corresponding ESD Competencies	Students present
Frontal lecture	Second life options for products, life cycle assessment method		No
Group session and guided group discussion	Students teach ecodesign, conjoined thinking of possible appliances in company	Strategic Thinking and collaboration competence	Yes
Individual and group assignments	Using ecodesign tools for quick sustainability assessment	Strategic thinking competence	No

Source: Own elaboration

Three main evaluations are planned for TIM, two of which were already carried out. The participants were given digital questionnaires which were anonymously and non-obligatory and could be filled out over a predetermined time period. In these two evaluations, a total of five and three participants participated respectively. The first evaluation was open from 24th of April until 16th of June 2023 and took place before the learning cooperations at BUAS. This feedback concerns other learning cooperations carried out in this project. The second evaluation was open from 27th of October until 3rd of December and thus covered the ecodesign learning cooperation as well as the first half of the scenario development learning coopera-

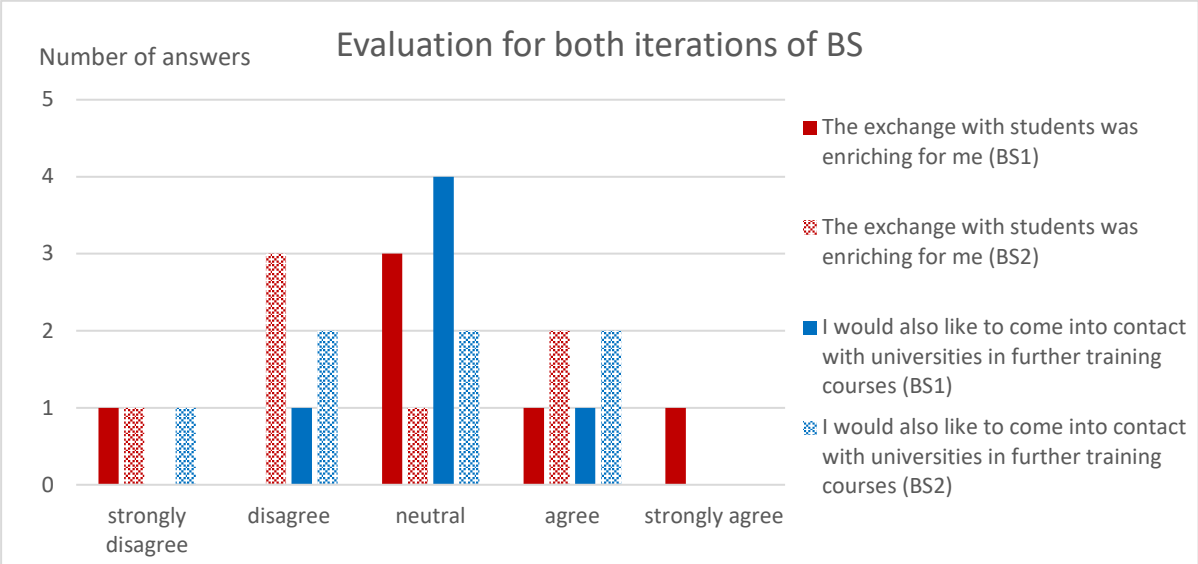
BY-NC-SA 2024, Editorial Universitat Politècnica de València

tion. After each month, the participants were given another digital, anonymous, non-obligatory questionnaire which is a shortened version. This questionnaire only asks for a grade and open questions what the participants liked, what they disliked and what they want improved. To supplement these, feedback was gathered after the learning cooperations, from the students and teachers in an open non-formal conversation in the open classroom. Additional evaluations were done through personal talks which could not be considered for this study.

4. Results

The results of the evaluation of BS1 can be seen Fig. 2. Note that these evaluations are for the entire programme which contained other learning cooperations as well.

Fig. 2– Results of the evaluations of BS, BS1: n=6, BS2: n=7



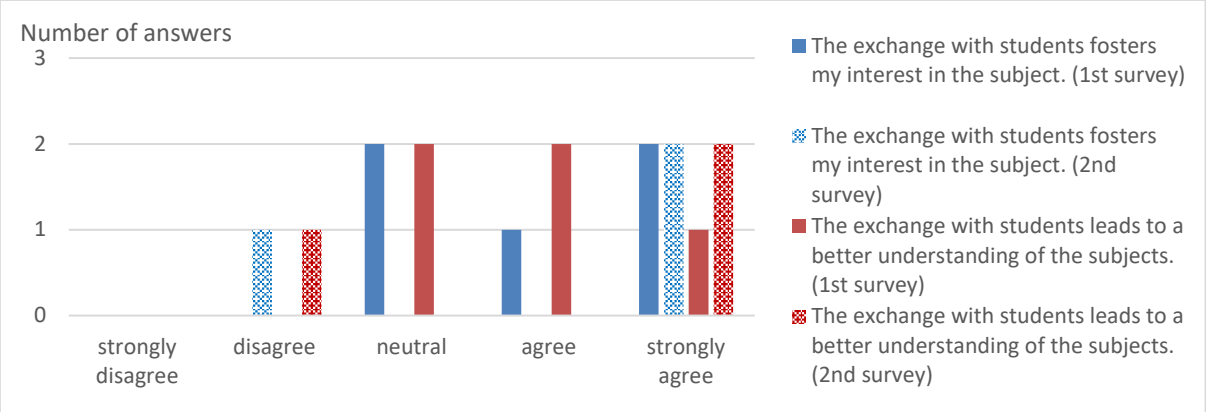
Source: Own elaboration

Additionally to these results, the feedback gathered from the participants directly after the learning cooperations showed that they are unsure how the learned subjects help them in their work. They also mentioned the group sessions positively as an opportunity to discuss ideas as well as negatively as they fear they would not learn anything: "Even though I am not a friend of long group sessions, there were many opportunities for discussions which made everything positively interesting.". The students expressed that they enjoyed the development of concepts in the group sessions with partners who work in the industry.

The results from the first and second evaluation of TIM can be found in Fig. 3.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 3 – First and Second Evaluation of TIM, 1st survey: n=5, 2nd survey: n=3



Source: Own elaboration

After these learning cooperations, the students expressed that they gained a more applied perspective and learned about the challenges transport companies are facing. They also enjoyed the development of concepts in the group sessions similarly to the learning cooperations in the BS programme.

The teachers observed the interaction between students and stated the participants worked well without any additional need to connect these two groups. The developed concepts were of good quality combining the theoretical and practical knowledge of both groups. The students were more experienced in presenting and writing down the concepts whereas the participants were able to give practical insights.

5. Discussion and Conclusion

In this study, the conceptual integration of ESD skills into VET via learning cooperations with students studying sustainability related programmes looks promising. As learning cooperations have their greatest benefit in the combination of groups with different educational backgrounds, this leads to them being naturally fit for teaching *skills* rather than just conveying knowledge through lectures. This allows for the integration of ESD into further VET which is still lacking sufficient ESD.

The results show that the exchange of viewpoints between a theoretical (students) viewpoint and an applied (participants) received mixed feedback. This stands in contrast to the success and growing numbers of the dual study system in Germany (Nickel et al., 2022). The participants of TIM however viewed the learning cooperations more positively than the participants of BS. This implies that learning cooperations could be better suited for higher level further VET or for participants who are interested in more theoretical learning.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

This study however was limited by some factors. Due to the frequent evaluation of the participants during the course, it was not possible to implement a detailed evaluation of the presented learning cooperations. The sample size of participants as well as days of teaching are small. Whether the participants and students gained the respective ESD skills is difficult to test as these type 2 skills are built over time and would require a longer period of evaluation.

As the concept of learning cooperations in further VET is still new, future research should focus on implementing more instances of learning cooperations into further VET as well as in the curriculum of universities. To assess the gained ESD skills, larger scale studies need to be done. The gained knowledge of the students should also be evaluated in greater detail.

Acknowledgements

The project 'UpTrain' is funded by the German Federal Ministry for Research and Development (BMBF) as part of the InnoVET projects.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bundesinstitut für Berufsbildung. (2024, January 25). *Höherqualifierende Berufsbildung: Karriere mit Beruf* [Article]. Bibb. https://www.bibb.de/de/142826.php

European Commission, Directorate General for Employment, Social Affairs and Inclusion. (2021). *Osnabrück Declaration on vocational education and training as an enabler of recovery and just transitions to digital and green economies.* Publications Office. https://data.europa.eu/doi/10.2767/784423

Langfeldt, B. (2018, June). Lernortkooperation im dualen Studium – zu viel oder zu wenig Einfluss der Hochschulen auf die betrieblichen Praxisphasen? *Berufs Und Wirtschaftspädagogik Online*, *34*.

Nickel, S., Pfeiffer, I., Fischer, A., Hüsch, M., Kiepenheuer-Drechsler, B., Lauterbach, N., Reum, N., & Thiele, A.-L. (2022). *Duales Studium: Umsetzungsmodelle und Entwicklungsbedarfe*. wbv Publikation. https://doi.org/10.3278/9783763971718

Rieckmann, M. (2016). *Kompetenzentwicklungsprozesse in der Bildung für nachhaltige Entwicklung erfassen – Überblick über ein heterogenes Forschungsfeld*. https://www.researchgate.net/publication/298722020_Kompetenzentwicklungsprozesse_in_der_Bildung_fur_nachhaltige_Entwicklung_erfassen_-_Uberblick_uber_ein_heterogenes_Forschungsfeld

SEED Online Platform. (2024, January 25). [Forum]. Online Platform SEED. https://platform.coveseed.eu/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

UNECE - Committee on Environmental Policy. (2005). *UNECE STRATEGY FOR EDUCATION FOR SUSTAINABLE DEVELOPMENT*. United Nations - Economic and Social Council - Economic Commission for Europe.

Vare, P., & Scott, W. (2007). Learning for a Change: Exploring the Relationship Between Education and Sustainable Development. *Journal of Education for Sustainable Development*, *1*(2), 191–198. https://doi.org/10.1177/097340820700100209

Wiek, A. (2011). *Key competencies in sustainability: A reference framework for academic program development*.

Wiek, A. (2016). *OPERATIONALISING COMPETENCIES INHIGHER EDUCATIONFORSUSTAINABLE DEVELOPMENT*.

Wiek, A., Withycombe, L., Redman, C., & Mills, S. B. (2011). Moving Forward on Competence in Sustainability Research and Problem Solving. *Environment: Science and Policy for Sustainable Development*, *53*(2), 3–13. https://doi.org/10.1080/00139157.2011.554496

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

BIM4CLIMATE: Project-Based Learning to enhance students' engineering skills within a CampusLab

Blanca Tejedor [a], Maria Sampaio [a], Núria Forcada [a], Francesc Trisan [a], Aleix Rifà [a], PaulaGordo [a], Marta Gangolells [a]

[a] Department of Project and Construction Engineering, Group of Construction Research and Innovation (GRIC), Universitat Politècnica de Catalunya, Spain.

Abstract

BIM4CLIMATE aims to implement a PBL approach in construction engineering courses within the UPC CampusLab. The developed methodology serves as a catalyst for the comprehensive digitization and management practices of all university buildings.

Keywords: PBL; CampusLab; engagement, construction engineering studies.

How to cite: Tejedor, B.; Sampaio, M.; Forcada, N.; Trisan, F.; Rifà, A.; Gordo, P. and Gangolells, M. (2024) BIM4CLIMATE: Project-Based Learning to enhance students' engineering skills within a CampusLab. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 580-588. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The project BIM4CLIMATE is a cutting-edge project that aims to analyze the benefits of PBL using university campuses as real scenarios for students, to enhance academic performance and increase engagement.

Project-based learning (PBL) is a dynamic and student-centered approach in which students learn about a subject by working in groups to solve real-world problems, demanding a range of skills from the learner (Wells et al., 2009). PBL allows students to engage in authentic, real-world problems and scenarios. This helps bridge the gap between theoretical knowledge and practical application and help students develop a deeper understanding of the subject. Projects are often more engaging for students compared to traditional classroom activities.

This article delves into the innovative BIM4CLIMATE project, incorporating a PBL approach in three construction engineering courses within the UPC CampusLab in ESEIAAT and ETSEIB, involving 60 students. The expected outcomes encompass improved practical skills, enhanced teamwork abilities, the promotion of sustainability, and a greater understanding of theoretical content related to advanced modeling and building facilities. Additionally, the project pretends to bring positive changes to the institution, influencing building management practices and serving as a catalyst for the comprehensive management of all university buildings.

This project comprised three primary steps. First, identifying and selecting UPC campus case studies and collaborative tools for student use. Second, implementing this new methodology across the different courses. The final step, detailed in this study, involved analyzing and evaluating the methodology's outcomes through final grades and a student questionnaire administered at the semester's end. Hence, this paper aims to present the PBL-CampusLab methodology implemented in the BIM4CLIMATE project and its impact on the academic community. Results of the BIM4CLIMATE implementation during the first semester are also presented in the paper. This paper starts with the state-of-the-art PBL and the description of the BIM4CLIMATE project.

2. State of the art

2.1 BIM4Climate project

The project BIM4CLIMATE emerges as a pioneering initiative, within the UPC (Universitat Politècnica de Catalunya), to implement Project Based Learning (PBL) within the context of a CampusLab to improve students' results and engagement with the university. Thus, this project aims to have a strong impact on the management of UPC buildings and their adaptation and resilience to climate change, serving as a starting point for digitizing all the buildings. At the same time, the expected results on students are improvement of practical

BY-NC-SA 2024, Editorial Universitat Politècnica de València

skills, development of teamwork skills as well as, raising awareness of sustainability among the students involved, and increasing their engagement with the university.

2.2 Project based learning and CampusLab

PBL is a dynamic and student-centered approach in which students learn about a subject by working in groups to solve real-world problems, demanding a range of skills from the learner. These skills include: self-directed learning, critical thinking, team participation and acquisition of critical knowledge (Wells et al., 2009). Moreover, the chosen project for experimentation should be captivating enough to motivate students, promote commitment and dedication and lead to meaningful learning. On this basis, PBL supports constructivist learning in which students build knowledge instead of being simple recipients of it (Lopez-Gazpio, 2022).

In this context, LivingLab illustrates the concept of innovation within real-world scenarios, involving active engagement from users, businesses, and governments. An essential aspect of living labs is that users play a collaborative role in the innovation process rather than merely serving as observed subjects. Additionally, living labs function within an actual production environment (Althaus et al., 2022). Specifically, when a university campus is used, a LivingLab is called CampusLab. Universities function as a scientific community committed to research activities and the creation and advancement of knowledge, expertise, and innovation in several domains. Consequently, a university campus can effectively work as a CampusLab facilitating the smoother translation of research studies and findings into practical applications (Vezzoli & Penin, 2006).

2.3 Existing experiences

Lopez-Gazpio (2022) and Habash et al.(2017) have already analyzed the impact of PBL and students´ engagement. Lopez-Gazpio (2022) studied how PBL combined with game construction can be used to promote engagement in informatic lectures at university. For that research, students adopted a series of sequential phases, comprising a set of milestones designed to integrate a PBL approach into the artificial intelligence classes. As teams of students progressed through the outlined phases, they created intelligent agent players that applied artificial intelligence techniques to solve the given game. To evaluate the increase in students' motivation comparison of grades and answers to final questionnaires were used. Results showed that PBL increased the engagement of students through the semester.

Habash et al., (2017) implemented a PBL within CampusLab. In this case, they used the campus buildings as a "real-space sustainability lab" for creating educational material and gathering data for engineering design projects of undergraduate courses. The analysis of the surveys, interviews, and observations done at the end of the process, indicated that incorporating PBL-CampusLab can notably enhance students' analytical thinking, reflective

2024, Editorial Universitat Politècnica de València BY-NC-SA

judgment, and self-efficacy. Moreover, they concluded that an important outcome of this process was making students knowledgeable about the campus and engaging them in the buildings they study in.

3. Methodology

A PBL-CampusLab was implemented in three different subjects from engineering studies at the Universitat Politècnica de Catalunya during the first semester of 2023. A questionnaire survey was developed to evaluate the impact of the PBL-CampusLab on the engagement of students and their results on the subject. Conclusions and recommendations were drawn up to extend the initiative in other subjects.

3.1 PBL-CampusLab implementation

In this project, PBL was implemented in Building systems; Asset and facility management and Building energy management subjects (see table 1).

Table 1. Selected subjects

Course	Degree	Credits (ECTS)
Building Systems	Master degree in Industrial Engineering	5
Asset and facility management	Master degree in Management Engineering	3
Building energy management	Master degree in Building Construction Management	5

Source: Own elaboration

Building Systems is a subject from the second semester of the Master's degree in industrial technology from The School of Industrial, Aerospace and Audiovisual Engineering of Terrassa (ESEIAAT) from Campus Terrassa (UPC) (See Figure 1). It aims to provide students with the skills to design and plan building systems of whatever building including Heating, Ventilation and Air Conditioning (HVAC, electrical systems and water systems.

Asset and facility management is a subject from the third semester of the master's degree in management engineering from the ESEIAAT. It provides the knowledge, tools, and skills necessary to successfully coordinate and manage space, infrastructure, people, and assets within organizations.

Building energy management, is a subject from the second semester of the master's degree in building construction management from Escola Politecnica d'Edificació de Barcelona (EPSEB) (See Figure 2). It provides the student with the necessary knowledge, skills, and competencies for the implementation of energy management systems, the conduct of energy audits, and the identification of technically and economically viable energy efficiency

BY-NC-SA 2024, Editorial Universitat Politècnica de València

measures. Throughout the semester, depending on the course, the students develop a different project but always work with the university campus as a case-study.

Building systems students work in groups to design the facilities of a given building (e.g., HVAC, hot and cold water sanitary system, drainage, electricity, fire safety, etc.). For this project, the case study was TR5 from ESEIAAT, where students had lessons or laboratories. Although the buildings already exist, the aim of the PBL-CampusLab project was to propose a new, more optimal, and sustainable building systems design. For the PBL-CampusLab students in the Asset and Facility Management subject also join in groups to propose Facility Management (FM) measures for the Terrassa campus including ESEIAAT buildings. Students identified existing installations, organizational structure (including how FM services were managed), asset list, preventive maintenance plan (if any), corrective maintenance plans, tools, and applied technology (CMMS (Computerized maintenance management system), BMS (Building management system, BIM (Building Information Modeling)). The work in the subject focused on obtaining the Well certification, proposing Key Performance Indicators (KPI), energy-saving measures, safety and health measures for occupants, proposal for the incorporation or adaptation of management systems, proposal for new layouts (Flex Work), sustainability management, facilities information management, communication, among others.

Fig. 1 – ESEIAAT Campus (left) and EPSEB Campus (right)



Source: UPC, 2024

Finally, the PBL-CampusLab in the Building Energy Management subject involved modeling energy consumptions, implementing energy efficiency measures (primary/secondary/tertiary), and assessing their economic viability for five UPC buildings (FME, Vértex, ETSEIB, EPSEB, Gabriel Ferraté Library). This approach allowed on-site visits to gather information such as floor plans, energy certificates, historical electricity cost data, and technical specifications of equipment. Additionally, they could conduct interviews with infrastructure/maintenance personnel to gather more information.

2024, Editorial Universitat Politècnica de València BY-NC-SA

3.2 PBL-CampusLab Evaluation

The evaluation of the results was divided into two categories: acceptability and impact on learning, where the two main ways to collect data are feedback forms and performance tests (like exams)(Camelia & Ferris, 2018) Acceptability focuses on analyzing students' reactions using surveys, Google Forms in this particular case, which they answered at the end of the semester. Through these questionnaires, it is expected to understand to what extent students find the experience motivating, useful, and relevant to their education, as well as, whether they believe that what they have learned will be applied in their future professional life. Concerning the impact on learning, it is based on assessing the knowledge, skills, and competencies they have acquired with this new teaching methodology through questionnaires. Once the results of the conducted studies were obtained, they were compared with the grades of students' evaluative tests to observe whether there had been an improvement in teaching quality and learning.

3.3 Evaluation Questionnaire Development

The development of the questionnaire was a key point to subsequently evaluate the efficacy of the current project, along with the acceptance and adaptability of the students with the PBL-CampusLab.

The first two sections of this survey intended to characterize the students (gender, age, country) and their background on PBL previous experiences. The following section aimed to comprehend the influence that PBL had on students in terms of specific areas of knowledge (like building management, building management systems, importance of sustainability) by assessing their understanding levels before and after the project. The fourth section focused on rating the students 'engagement in the subject when a PBL is performed. Engagement consists of cognitive, behavioral, and emotional dimensions. The first is the active process of learning. It focuses on the learner's psychological investment in learning. The behavioral engagement concerns participation and involvement and is often measured by attendance and time spent, usually characterized by positive conduct, class participation, involvement in the learning task, high effort and persistence. The last type of engagement can be perceived through students' attitude, enthusiasm and interest (Sahari Ashaari et al., 2020). The questions about engagement and students 'motivations were based on a Likert scale, from 1 to 5 (1) totally disagree; 3-neutral; 5- totally agree). Finally, the last part, aimed to study the advantages of using the PBL-CampusLab, asking the students if they saw the benefits of working in a familiar environment.

4. Results and discussion

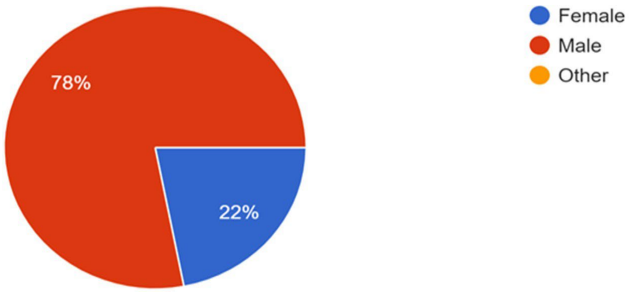
After implementing the PBL-CampusLab initiative in the three subjects, the evaluation questionnaire was provided to all students through the Atenea intranet, the UPC's virtual

BY-NC-SA 2024, Editorial Universitat Politècnica de València

teaching environment, which professors use to provide students with teaching material, statements of practical problems, exercises and sample exam papers, etc.

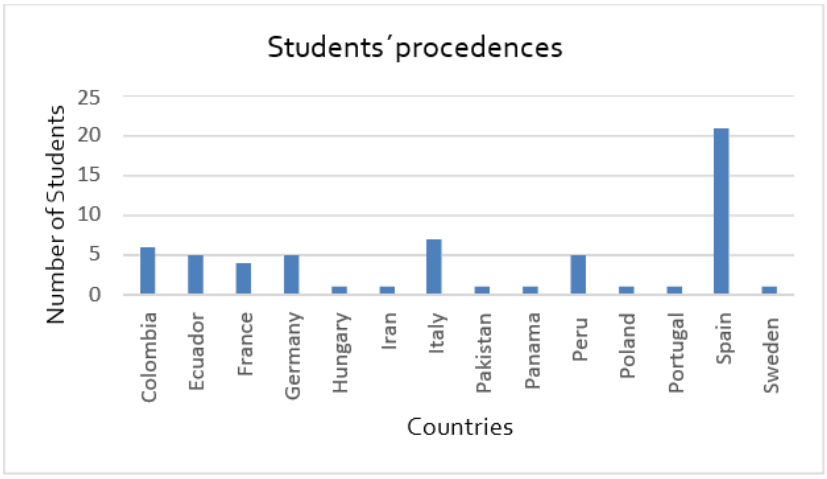
60 responses were collected, with an average participant age of 25.4 and 78% originating from male respondents and 22% from female respondents (see Figure 2). This gender distribution is attributed to the persisting gender disparity within construction engineering courses, where male participation tends to outnumber that of females. As illustrated in Figure 3, the predominant demographic comprises Spanish students. Nevertheless, the survey also reflects a diverse representation, with participants hailing from 13 additional countries spanning three different continents.

Fig. 2-% of male vs female



Source: Own elaboration

Fig. 3 - Students´procedences



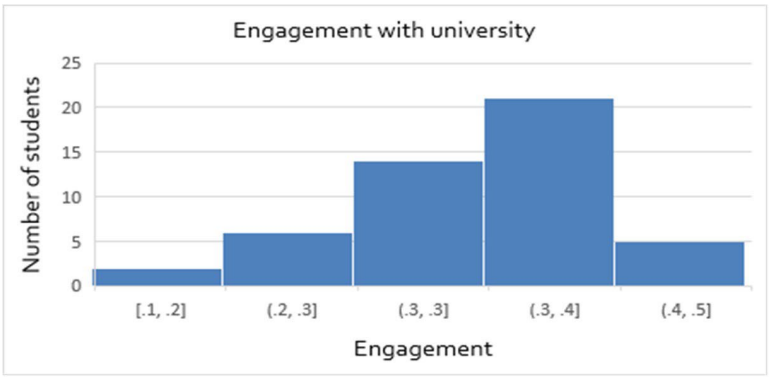
Source: Own elaboration

Figure 4 shows the results regarding the engagement of students. The majority of the students classified their engagement with the university after the PBL-CampusLab experience as good-4, which is an effective representation of this methodology. Moreover, the survey done shows that "increase the interest of the subject", "understand the subject topics", "increase participation" and "increase attendance to classes" all had an evaluation mean of 4 (good) except for the latter where the mean was of 3.1 , validating that with PBL learners report an

 BY-NC-SA

increase of satisfaction and participation in classes (Kilgour et al., 2016).

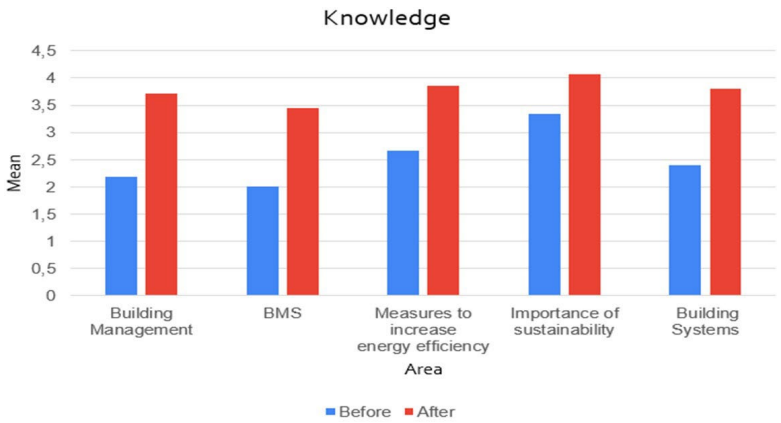
Fig. 4- engagement with university



Source: Own elaboration

Finally, we conclude that PBL increases the degree of knowledge in areas like Building management, BMS, and the importance of sustainability (fig.5) when comparing the previous and post-knowledge, confirming the idea that learning, understanding, and reflecting on the content become more meaningful when they lead to action (Habash et al., n.d.)

Fig 5 - Comparison of the degree of knowledge



Source: Own elaboration

5. Conclusions

This article aims to understand if the implementation of PBL in construction engineering subjects increases their engagement with the university and their learning skills. For the task, this methodology was implemented in three different subjects in which students used the CampusLab to perform the project. The results analysis shows that students' interest and understanding of the topics increased with the execution of a project. Moreover, when comparing the knowledge in areas like Building management, BMS, and the importance of sustainability before and after the project, a significant increase is shown. Using the CampusLab scenario to develop the project also helps to increase the students' engagement

BY-NC-SA 2024, Editorial Universitat Politècnica de València

with the university. In conclusion, it is advantageous to implement this methodology in more engineering courses, whenever this is possible, as it has proven that these more focused on real-life applications projects are an effective form of learning and student engagement.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Althaus, P., Redder, F., Ubachukwu, E., Mork, M., Xhonneux, A., & Müller, D. (2022). Enhancing Building Monitoring and Control for District Energy Systems: Technology Selection and Installation within the Living Lab Energy Campus. *Applied Sciences (Switzerland)*, *12*(7). https://doi.org/10.3390/app12073305

Camelia, F., & Ferris, T. L. J. (2018). Validation studies of a questionnaire developed to measure students' engagement with systems thinking. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 48(4), 574–585. https://doi.org/10.1109/TSMC.2016.2607224

Escuela Superior de Ingenierías Industrial, Aeroespacial y Audiovisual de Terrassa. ESEIAAT, 2024 https://guies.bibliotecnica.upc.edu/com-citar/mitjans-digitals

Habash, R., Hasan, M., Chiasson, J., & Tannous, M. (2017). *Phenomenon-and Project- Based Learning Through the Lens of Sustainability**.

Kilgour, J. M., Grundy, L., & Monrouxe, L. V. (2016). A Rapid Review of the Factors Affecting Healthcare Students' Satisfaction with Small-Group, Active Learning Methods. Teaching and Learning in Medicine, 28(1), 15–25. https://doi.org/10.1080/10401334.2015.1107484

Lopez-Gazpio, I. (2022). Gaining Student Engagement Through Project-Based Learning: A Competitive 2D Game Construction Case Study. *IEEE Access*, *10*, 1881–1892. https://doi.org/10.1109/ACCESS.2021.3139764

Sahari Ashaari, N., Saleh Alfaqiri, A., & Fadzilah Mat Noor, S. (2020). *Exploring indicators of engagement: applications for gamification of online training systems*. *8*(4), 2096. https://www.researchgate.net/publication/348201280

Vezzoli, C., & Penin, L. (2006). Campus: "Lab" and "window" for sustainable design research and education: The DECOS educational network experience. In *International Journal of Sustainability in Higher Education* (Vol. 7, Issue 1, pp. 69–80). https://doi.org/10.1108/14676370610639254

Wells, S. H., Warelow, P. J., & Jackson, K. L. (2009). Problem based learning (PBL): A conundrum. *Contemporary Nurse*, *33*(2), 191–201.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Empowering Amazonian Communities Through Environmental Education and Technology

Carme Huguet[a] , Alba Ávila[b], Daniela Alvarez Gallo [a,c]

[a]Environmental Science and Sustainability group, IE University, Spain
[b]Electronic Engineering department, Los Andes University
[c]Bengo-Ednollano ONG.

Abstract

Illegal gold mining in Colombia threatens environmental and human health, especially in the Amazon region. The Guainía indigenous authorities have expressed concern over the surge in illegal mining activities, fearing detrimental effects on their community's health. Due to the remoteness of the area, there is no analytical infrastructure or regular environmental monitoring programs. Addressing this issue, we introduced user-friendly, eco-conscious 4-channel water probes and an extensive environmental education program. This empowered the community to identify water quality issues and trace contamination sources. A preliminary monitoring exercise was conducted to familiarize the community, teachers, and authorities with sensor usage, the importance of the information provided, and how to compare expected values with obtained ones. Our initial strategy, which included infographics, presentations, and community-collected data, fostered fruitful collaboration between researchers, Etnollano NGO collaborators, and the affected communities. After discussing the data with community leaders, they approved the project in their native land, highlighting the importance of community engagement and education in addressing environmental challenges. The project's second phase will introduce the portable sensors to make the community fully autonomous in gathering environmental quality data and reporting them. This will enable them to make informed decisions about environmental management and regulation in the affected areas.

Keywords: Contamination; community education; water sensors; Guainía River; gold mining.

How to cite: Huguet, C.; Ávila, A. and Álvarez Gallo, D. (2024) Empowering Amazonian Communities Through Environmental Education and Technology. In proceedings: Conference on Sustainable Energy Education – SEED 2024. 589-596. Valencia, Spain, 3 - 5 July 2024. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Environmental education enables communities to address the impacts of human activities (Boiral et al. 2020; Wilson et al., 2018). Indigenous peoples, particularly in Guainía, Colombia, bear significant burdens of pollution due to commodity frontiers (Fernández-Llamazares et al., 2019; Gonzalez, 2018). Here, extraction of gold, tantalum, and coltan disrupts alluvial sediments and river courses, affecting ecosystems and communities (Burbano-Pérez, 2019). The separation of the mineral is done using mercury in a process called "amalgamation", frequently leading to the improper handling of hazardous waste. A 2017 study found that Guainía communities have mercury levels 60-109 times higher than the World Health Organization's limit, affecting both miners and non-miners (Olivero-Verbel et al., 2016; Gonzalez, 2018). This suggests indirect exposure through diet, which is confirmed by mercury concentration in fish, surpassing WHO's maximum permitted levels in the Atabapo River (Figure 1; Cacéres et al, 2019). These findings underscore the urgent need for a robust environmental education framework to address these issues effectively.

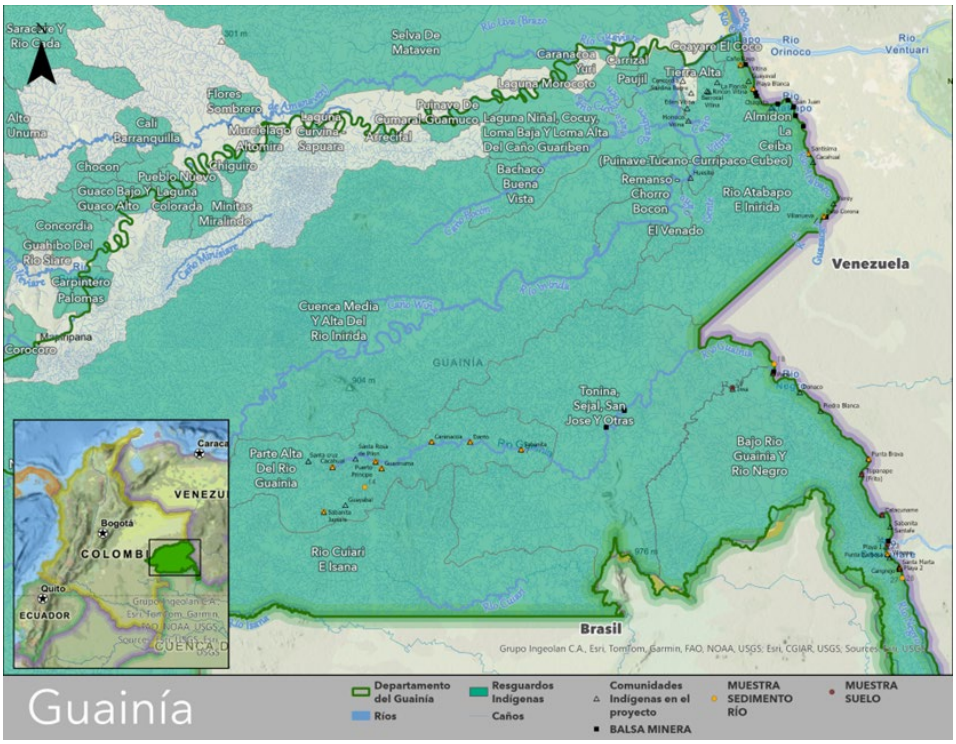
This project aims to confront the pressing environmental health crisis through a collaborative effort involving researchers, NGO collaborators, and Amazonian communities. Utilizing the translational environmental science approach, we will bridge the gap between fundamental science and its practical applications, policy implications, and accountability (Kaufman & Curl, 2019). This methodology not only enhances the impact of scientific research but also ensures its relevance and applicability to real-world scenarios. By fostering a strong partnership between researchers and the community, we aspire to create a sustainable solution to the environmental challenges faced by the Amazonian communities of the Guainía basin. This approach is structured into four distinct steps:

1. Identification of Contamination Sources
2. Understanding Contaminant Movement
3. Mapping Community Exposure
4. Development of Environmental and Public Health Practice and Policy.

The primary objective of this project is to empower the lower Guainía River communities, who are affected by the pollution from illegal mining activities upstream, to monitor environmental health. Despite varying degrees of educational access across the Guainía River basin, an indigenous knowledge system persists, ensuring territorial permanence and conservation. However, illegal mining introduces Western knowledge systems for gold extraction. Monitoring and understanding the river's contamination requires a convergence of knowledge, where community understanding of the forest meets Western academic measurement tools. To facilitate this, we incorporated a multilevel engagement approach.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Figure 1. Map of the Guainía River with the communities involved in the project (triangles). The Sediment and soil samples taken for preliminary assessment are indicated by yellow and brown dots.



Source: Own elaboration

2. Problem statement

Illegal gold mining in Colombia's lower Guainía River region releases heavy metals, posing environmental and health risks (Gonzalez, 2018; Olivero-Verbel et al., 2016). These non-metabolizable metals bioaccumulate, causing toxic effects and increasing morbidity and mortality (Rodriguez-Arcila, 2019). Indigenous authorities are concerned about the illegal gold rush impact on the population but lack governmental support. Given the area's isolation and lack of monitoring infrastructure, it's vital to empower local communities with environmental monitoring skills and tools.

3. Methodology

3.1. Community engagement

Active participation empowers communities to protect their environment by fostering ownership and responsibility. It also promotes the exchange of local knowledge and scientific research, leading to sustainable solutions (Boiral et al. 2020; Wilson et al., 2018). Our engagement activities included infographic dissemination, informal community discussions, and a preliminary citizen science project for pollution monitoring.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Infographics, effective tools for conveying complex information, were used to help the community understand the impacts of illegal mining, specifically mercury (Albers, 2015).

The preliminary citizen science project was done using a commercial sensor for field measurements of water quality, involving community participation to raise awareness of the issue and engage the community into acting (Fig. 2b).

Additionally, we collected and analysed two sediment samples at Prof Widory's laboratory at UQAM. The enrichment factor (EF) was computed to show the degree of enrichment of an element in a sample compared to its natural occurrence (Fig. 2c; Pastorinho et al., 2012).

3.2 Water quality sensors

Our citizen science initiative's second phase employs SensoAgua, a green-powered water sensor developed at Los Andes University labs. Deployed in various Colombian rural communities, it monitors key electrochemical water quality parameters (Bernalte et al., 2020). The sensors detect heavy metal ions (Pb^{2+}, Cu^{2+}, and Hg^{2+}) in water within 60 seconds, correlating their presence with potential mining activities nearby with a single screen-printed electrode-based probe (Bernalte et al., 2020).

On-site testing and monitoring demands techniques that do not require ample pre-treatment and robust equipment such as amperometric measurements with modified electrodes with ionophores that reversibly binds Hg ions at concentrations near those declared poisonous by the EPA and WHO (5-15 nM) for on-site testing (Ariño et al., 2017).

The probe, controlled via a mobile app, explores the relationship between water's electrochemical properties and heavy metals presence. Data is stored, visualized, and uploaded to a platform called Monitoreo Ciudadano (https://monitoreociudadano.uniandes.edu.co/). Already deployed in seven Colombian communities, it forms part of an evolving project encompassing citizen monitoring, data communication, and a user interface for data handling (Dubay, et, al., 2022).

4. Outcomes and outlooks

This project has successfully achieved the four steps delineated in the introduction (Kaufman & Curl, 2019).

The initial phase involved crucial conversations with the community, who were instrumental in identifying pollution sources due to their knowledge of the area's extraction operations. Preliminary assessments of pollutant transport were conducted using a commercial sensor and sediment sample analysis.

The second step of the translational is essential for the community to understand the interconnectivity of environmental, animal, and human health.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The community, having gained an understanding of mercury dynamics through infographics and informal discussions, assisted in mapping exposure points. The second phase will introduce self-powered water quality sensors to the community, facilitating self-regulated environmental monitoring.

The information collected in the first three phases will be transformed into informed decisions, public health practices, and regulations. As the community directly impacted, they possess an intrinsic and fundamental motivation to improve their knowledge of environmental health.

4.1. Community engagement

The project's initial phase has been a success, marked by the active engagement of the community. Firstly, the community was able to grasp the gravity of the problem at hand, thereby understanding the necessity of our project. Secondly, they recognized the utility and potential impact of our project's objectives, further solidifying their support. Thirdly, the preliminary citizen science activities were met with enthusiasm, leading to expressed interest from the community to continue their involvement. Lastly, the local authorities have not only granted us permission to operate in the area but have also expressed their willingness to utilize the project's outcomes for environmental governance.

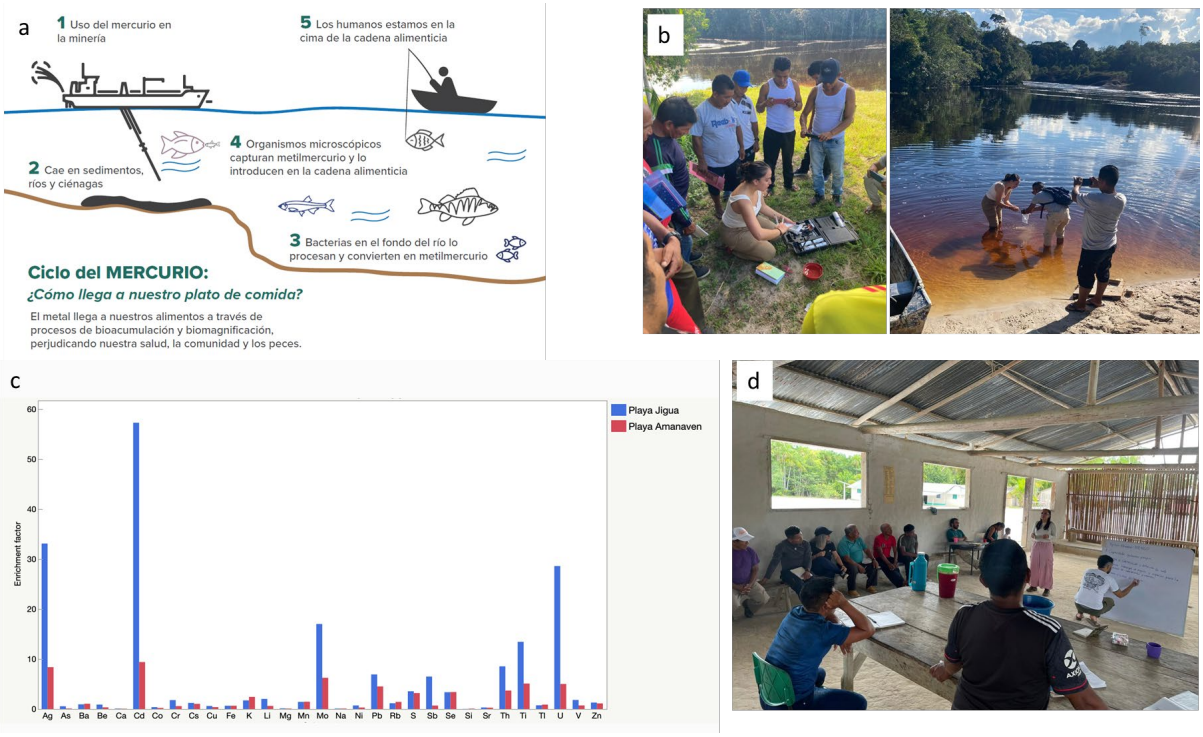
This successful first phase has laid a strong foundation for the project, promising a significant impact on education and environmental governance.

The project commenced with the dissemination of an infographic detailing exposure paths and health impacts in schools, with additional information provided to teachers (Fig. 2a). This infographic was also shared with territorial authorities, initiating a consultation process to build sensors, start monitoring, and foster community participation on the effects of illegal gold mining on community health and their dependent ecosystem (Fig. 2b and c). The infographic played a crucial role in raising community awareness about the issues at hand, as well as the contamination pathways and potential exposure points (Fig. 2b). This was a critical step to foster project acceptance, stimulate participation motivation, and enhance community understanding of the impacts of gold mining in the area.

The initial survey and preliminary sediment analysis data were shared first with the indigenous governing bodies and then the community at large to explain the relevance of the intended intervention (Fig. 2 c and d).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 2. Community engagement, a) Infographic shared at Guarinuma and Punta Barbosa community schools to promote and improve understanding of the theme; b) Use of a commercial sensor with the community at Higher Guainía so that they experience environmental monitoring firsthand, c) Preliminary results of enrichment factor of two river sediments (locations indicated in Fig. 1); d) Sharing of preliminary information with the indigenous authorities. Source: Own elaboration



Source: Own elaboration

This initial monitoring exercise aimed to familiarize the community, teachers, and authorities with sensor usage, the importance of the information they provide, and how to compare expected values with obtained ones. Following this, the project received approval from territories' authorities (Fig. 2d).

5. Conclusions and Perspectives

The community's active involvement in sample collection and preliminary water quality assessments, facilitated by a commercial sensor, has not only equipped them with the necessary skills to fully implement the project but also significantly enhanced their motivation to participate (Fig. 2b and d). The community now firmly believes that their contribution is not just feasible, but indeed crucial (personal communication to DAG).

Following the construction of the sensor, a comprehensive training program will be initiated, with a focus on environmental leaders within the governmental structure of the two participating indigenous territorial entities, as well as schoolteachers.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The portable sensors are scheduled for deployment across five distinct communities within the Guainía River basin, commencing at the end of May 2024.

Research has demonstrated that the integration of Indigenous environmental governance and scientific studies can significantly bolster environmental regulation in critical areas (Wilson et al., 2018; Boiral et al., 2020). Involving indigenous communities in environmental matters can lead to several benefits. For example, improve our knowledge of local ecosystems and strengthen environmental monitoring efforts (Boiral et al., 2020).

Upon the successful completion of the current project, we aim to expand the program to other remote regions in Colombia that are under the threat of mining activities.

Acknowledgements

The Guainía River indigenous authorities and Etnollano are thanked for their cooperation and support, which were crucial to the project's success. Juan Camilo Gonzalez is acknowledged for his sustained support in the project's design and implementation. We thank the IEEE Humanitarian Technologies Board for funding project 23-HTB-130, awarded to AAB and CH. Finally, Prof. Widory at UQAM is thanked for conducting geochemical measurements in sediment samples and providing ongoing support for the project.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Albers, M. J. (2015). Infographics and communicating complex information. In Design, User Experience, and Usability: Users and Interactions: 4th International Conference, DUXU 2015, Held as Part of HCI International 2015, Los Angeles, CA, USA, August 2-7, 2015, Proceedings, Part II 4 (pp. 267-276). Springer International Publishing.

Ariño, C., Serrano, N., Díaz-Cruz, J. M., & Esteban, M. (2017). Voltammetric determination of metal ions beyond mercury electrodes. A review. Analytica chimica acta, 990, 11-53.

Bernalte, E., Arévalo, S., Pérez-Taborda, J., Wenk, J., Estrela, P., Avila, A., & Di Lorenzo, M. (2020). Rapid and on-site simultaneous electrochemical detection of copper, lead, and mercury in the Amazon River. Sensors and Actuators B: Chem., 307, 127620.

Boiral, O., Heras-Saizarbitoria, I., & Brotherton, M. C. (2020). Improving environmental management through indigenous peoples' involvement. Env. Sci. & Pol., 103, 10-20.

Burbano-Pérez, K. (2019) Centro de Estudios de la Orinoquia – CEO, https://repositorio.uniandes.edu.co/server/api/core/bitstreams/d83e1670-222d-42ac-a2e2-7ff4cb936b48/content (consulted 29-01-24)

Cáceres, C., Roberto, M. C., Dávila, C., Ortiz, P., Torres, J.C., Benjamín, A. (2019). Diagnóstico de las afectaciones ambientales por las actividades de explotación de yacimientos mineros

BY-NC-SA 2024, Editorial Universitat Politècnica de València

en los departamentos del Guainía y Vaupés. Corporación para el Desarrollo Sostenible del Norte y el Oriente Amazónico.

Dubay, D. R., Pinto, J. A. P., Taborda, C. G. F., Rodriguez, Gomez-Martinez R., and Avila, A. (2022), "Water quality probe co-design for water monitoring in rural communities in Colombia," IEEE International Humanitarian Technology Conference (IHTC), Ottawa, ON, Canada, 2022, pp. 124-128, doi: 10.1109/IHTC56573.2022.999833

Fernández-Llamazares, Á., Garteizgogeascoa, M., Basu, N., Brondizio, E. S., Cabeza, M., Martínez-Alier, J& Reyes-García, V. (2020). A state-of-the-art review of indigenous peoples and environmental pollution. Int. Env. Ass. and Man., 16(3), 324-341.

Kaufman, J. D., & Curl, C. L. (2019). Environmental health sciences in a translational research framework: more than benches and bedsides. Env. Health Pers., 127(4), 045001.

Olivero-Verbel, J., Carranza-López, L., Caballero-Gallardo, K., Ripoll-Arboleda, A., & Muñoz-Sosa, D. (2016). Human exposure and risk assessment associated with mercury pollution in the Caquetá River, Colombian Amazon. Env. Sci. and Pol. Res., 23, 20761-20771.

Pastorinho, M. R., Telfer, T. C., António, J., Nogueira, A., Amadeu, M., Soares, M., & Ranville, J. F. (2012). An evaluation of trace metal distribution, enrichment factors and risk in sediments of a coastal lagoon (Ria de Aveiro, Portugal). Env. Earth Sci., 67(7), 2043.

Pérez-López C. A., Pantoja W, J. A. Perez-Taborda, Avila A. (2023) PortAqua: a low cost, compact water quality meter for science communication. Env. Mon. and Ass. (ISSN 0167-6369) 336 (195), pp. 1-13.

Rodríguez-Arcila, L. V. (2019). Caracterización de la concentración de metales en agua, sedimentos y suelos a lo largo del Río Quito (Chocó), zona de explotación de oro aluvial. Universidad de los Andes. https://repositorio.uniandes.edu.co/handle/1992/44787

Wilson, N. J., Mutter, E., Inkster, J., & Satterfield, T. (2018). Community-Based Monitoring as the practice of Indigenous governance: A case study of Indigenous-led water quality monitoring in the Yukon River Basin. Journal of Environmental Management, 210, 290-298.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Being effective when talking about Climate Change: an experience from the University of Trento (Italy)

Maria Giulia Cantiani[a]

[a]Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy

Abstract

At the beginning of the discourse on the concept of sustainability, the problem of climate change had not yet presented itself. However, it is increasingly becoming an essential component of the debate as it is closely connected with all aspects of sustainability. The topic must therefore be addressed using a highly interdisciplinary approach and requires the development of a language that cuts across the various disciplines: in this regard, higher education has a demanding but stimulating task and a huge responsibility. The paper illustrates an educational experience carried out at the University of Trento with the aim of getting teachers and students from different disciplines to talk about climate change. A seminar dedicated to an introduction to climate change was proposed during the academic year 2022–2023. The seminar, consisting of ten evening meetings, was intended for university students from all departments and all levels, from bachelor to PhD, and open to the general public. Teachers from different disciplines were involved in the course. This formula has been very successful and we plan to propose it again, taking into account the suggestions that came from the participants and broadening the audience, while at the same time also involving other disciplinary fields.

Keywords: sustainable development; climate change; higher education.

How to cite: Cantiania M.G.Cantiani, M. G.(2024)Being effective when talking about Climate Change: an experience from the University of Trento (Italy) Being effective when talking about Climate Change: an experience from the University of Trento (Italy). In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 597-602. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Although the effects of climate change have been felt manifestly in recent years and often with catastrophic results, people generally do not have a clear, scientifically founded perception of the problem. The alarmist tones with which the media often present the consequences of the climate crisis induce panic in some, and resignation in others. Unfortunately, unmindfulness is still widespread, despite the very existence of the phenomenon being acknowledged. However, among younger people – and mainly among those involved in higher education – the need for a better understanding of the problem is becoming increasingly widespread, not least to be able to adopt suitable tools for mitigation and adaptation in their future professional lives.

In numerous courses held in various universities, the topic has been debated for some time, but from a standpoint linked to the specific disciplinary field. This sometimes limits a broader and more general understanding of the problem and makes the exchange of knowledge and experiences difficult. Yet there is perhaps no topic more overarching and pervasive than the ongoing climate crisis, which affects all sectors of society.

The idea for an innovative approach to discuss climate change came from my experience as a teacher of the course in Ecology (Cantiani 2019), aimed at third-year students of the First Cycle Degree (BSc) in Environmental and Land Engineering at the University of Trento, Italy. When I started teaching this course in the early nineties, I understood that it was necessary to talk about climate change not only about the effects on ecosystems but also to try to mention all the social–, political– and economic implications linked to a climate crisis that is the direct result of the unsustainable development of modern societies (Plail, 2024). The students themselves, in 2010, asked me to talk about the various yearly Conference of the Parties (COPs) and to illustrate the effects of climate change from different perspectives and through concrete examples. I did my utmost, but after a few years I realized it was not enough: such a complex and multifaceted topic necessitated a highly interdisciplinary approach, and the idea of involving colleagues from other disciplines and putting forward an educational activity specifically dedicated to climate change placed outside the courses normally proposed by my university, began to take shape.

2. The experience from the University of Trento

For local historical reasons (https://www.unitn.it/en/ateneo/1694/history-of-the-university), at the University of Trento the scientific and technical departments are located on the so-called Trento hill, at the base of the mountain slope overlooking the city, while the others are located in the historic center of the city. This particular geographical location has, curiously enough, contributed to creating a sort of barrier between the two disciplinary fields, making communication and cultural exchange difficult. Given the situation, during the 2022–2023

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

academic year I proposed experimenting with an "Introduction to climate change" seminar divided into ten evening meetings, to be held in the conference room of the Economics department in the city center. The seminar was intended for university students from all departments and all levels, from bachelor to PhD, and also open to the public. Teachers from different disciplines were required to get involved in the course. The coordinator of the degree course in Environmental and Land Engineering welcomed the idea and the Department of Civil, Environmental and Mechanical Engineering promoted the educational initiative.

2.1 The first edition of the seminar, in the academic year 2022-2023

During the last academic year (2022-2023), the first edition of the seminar was tested, aimed at students of various degree courses mainly in the technical and scientific, and the economic and social fields. A small number of places (insufficient to satisfy the numerous requests) had also been reserved for people external to the university. In this first edition, the teachers involved came from the disciplinary areas of Atmospheric Physics, Ecology (experts in both terrestrial and marine ecosystems) and Law. It was decided, in this first edition, to explore in particular those issues relating to the effects of climate change on the earth's ecosystems. Since the University of Trento lacks marine ecosystem specialists, a colleague from the University of Naples, expert in oceanography, was invited. The presentations of the teachers involved were given in clear, accessible language, aimed at stimulating continuous interventions from all those present and were followed by a discussion. Since each meeting lasted more than two hours, when the topic turned out to be particularly sensitive and the discussion particularly lively, I organized for light refreshments to be served halfway through. At the last meeting, a case study was proposed, which was addressed through work in groups made up of participants with backgrounds in different disciplinary fields, and followed by a plenary discussion. At the end of the seminar, it was expected that all participants, fully able to understand the general aspects of the problem, would be able to bring their specific cultural background and their contribution to the discussion on mitigation and adaptation tools and actions. This formula has been very successful and we plan to propose it again, taking into account the suggestions that came from the participants and, by also involving other disciplinary fields, broad

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Poster of the first edition of the seminar: 2022-2023



Source: Department of Civil, Environmental and Mechanical Engineering (2023)

At the end of the course, each participant was asked to answer some questions relating to both the logistical aspects and the content of the seminar. Analysis of the data emerging from the survey has proved useful for better organizing the activities planned for the coming years. The idea of an introductory seminar on climate change was welcomed by everyone (a fact made evident right from the very beginning given that in just a few days the maximum allowable number of participants had been reached) and the participants appreciated the teachers' efforts to adapt the language and make complex topics accessible to all. Some repetitions and some gaps were noted, inevitable given that this was a first experiment, which failing can easily be remedied with greater coordination efforts between the teachers involved. The refreshment break offering small snacks was appreciated and contributed to creating a fruitful atmosphere of exchange and discussion, while the evening time slot was generally considered positive. Moreover, an in-person discussion with a small panel of students from different departments highlighted that there was a general consensus that the seminar had contributed to bridging the gap between different cultural backgrounds and producing a common language. It had also stimulated interest and curiosity for approaches other than the personal one to the analysis of the problem of climate change, an important prerequisite for future interdisciplinary collaborations.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2.2 The second edition of the seminar, in the academic year 2023-2024

The lessons learned thanks to the experience of the academic year 2022-2023 encouraged us to propose the seminar in the coming years, with the same formula and the recommendations made by participants. The second edition of the seminar will be held from March to April 2024. Compared with last year, we will try to stimulate even more active participation, which will make use of the contribution of the different skills linked to the specific cultural background of each participant. We expect to reserve at least 30 minutes for direct interaction with the participants. Participation will also be encouraged from students in the humanities, as well as from natural science teachers and final-year high school students. To facilitate broad participation, the seminar will be offered in a blended mode. During future seminars, some presentations will be dedicated to general topics, such as the scientific basis of climate change, while others will focus on a specific theme, to be explored in depth year by year. In particular, in the current academic year, we plan to delve deeper into the problem related to water availability (Figure 2). In this context, we are also planning to propose, at the end of the series of meetings, a round table to which youth associations dealing with climate change in the province of Trento will be invited.

Fig. 2 – Poster of the second edition of the seminar: 2023-2024



Source: Department of Civil, Environmental and Mechanical Engineering (2024)

The impact of the seminar on students will be evaluated through the number of enrolments, dropout– and access rates, as well as through specific questionnaires administered at the end of the course. Since the seminar is also aimed at ordinary citizens, it will be possible to evaluate its impact on civil society by considering the echo that the initiative has in the media and, in particular, the number of articles dedicated to it by the local press.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Conclusions

At the beginning of the discourse on the concept of sustainability (see, for example, Dixon and Fallon, 1989), the problem of climate change had not yet presented itself, but it is increasingly becoming an essential component of the debate, being, as it is, closely connected with all aspects of sustainability. This can easily be seen from the impressive number of publications on the subject. The topic must therefore be addressed using a highly interdisciplinary approach and requires the development of a language that cuts across the various disciplines: in this regard, higher education has a demanding but stimulating task and an enormous responsibility, one from which it cannot be exempted.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The author declares that she has no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Adeyeri, O.E., Zhou, W., Ndhedehe, C.E., Wang, X., Ishola, K.A., & Laux, P. (2024). Minimizing uncertainties in climate projections and water budget reveals the vulnerability of freshwater to climate change. *One Earth*, 7,72-87. https://doi.org/10.1016/j.oneear.2023.12.013

Cantiani, M.G. (2019). How to Teach Ecology to Students of Environmental Engineering. 5th International Conference on Higher Education Advances (HEAd'19), 703-710.`DOI: http://dx.doi.org/10.4995/HEAd19.2019.

Diaz Gonçalves, T. & Saporiti Machado, J. (2023). Origins of the Sustainability Concept and Its Application to the Construction Sector in the EU. *Sustainability*, 15, 13775. https://doi.org/10.3390/su151813775

Dixon J.A., & Fallon L.A. (1989). The concept of sustainability: Origins, extensions, and usefulness for policy. *Society & Natural Resources*, 2(1), 73-84. DOI: 10.1080/08941928909380675

Monforti-Ferrario, F., Crippa, M., & Pisoni, E. (2024). Addressing the different paces of climate and air quality combustion emissions across the world. *iScience* 27, 108686. https://doi.org/10.1016/ j.isci.2023.108686

Muniz, R. N., da Costa Júnior, C.T., Buratto, W.G., Nied, A. & González, G.V. (2023). The Sustainability Concept: A Review Focusing on Energy. *Sustainability*, 15,14049. https://doi.org/10.3390/su151914049

Plail, M. (2024). Sustainability for all. *Cell Reports Sustainability*, 1, 100016. https://doi.org/10.1016/j.crsus.2024.100016

University of Trento (2024). https://www.unitn.it/en/ateneo/1694/history-of-the-university

 BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Designing Courses & Increasing Learning Motivation through Gamification

Kim Möller[a] and Thomas Spelten[b]

[a]Academy of the Association of German Transport Companies, Germany
[b]Sustainable Technologies Laboratory, Bochum University of Applied Sciences, Germany

Abstract

Gamification, heralded for its potential to enhance learner motivation, deepen understanding, and promote engagement in education, has garnered significant attention. However, the empirical evidence supporting these claims remains scarce, particularly in Vocational Education and Training (VET) and specifically German VET. This proof of concept (POC) addresses the existing research gap by investigating the effects of gamification on students in VET, with a specific focus on the mechanics that constitute successful gamification and its potential support in teaching and learning. In response to this gap, we have implemented a gamification concept in our newly developed VET programme, the Certified Occupational Specialist for Electronics Mobility, aiming to complement sustainable education practices. Initial findings of a trial period without the use of gamification reveal challenges faced by students, whose teaching experience was rooted in vocational training, as they grappled with the unfamiliar structure of professional training. Issues included limited notetaking, missing intrinsic motivation for exam preparation, and difficulties "thinking outside the box." This paper synthesizes empirical evidence and theoretical underpinnings and connects them with our practical experience of applying gamification in a new VET programme, to provide insights into the complexities of gamification in VET. The results contribute a concise perspective to the academic discourse on the feasibility of gamification in this educational context, emphasizing the need for further research in this evolving field. Aiming to enhance student readiness and benefit from the Certified Occupational Specialist for Electronics Mobility, strengthens the public transport sector, thus supporting sustainability.

Keywords: gamification; vocational education and training; blended learning.

How to cite: Möller, K. and Spelten, T. (2024) Designing Courses & Increasing Learning Motivation through Gamification. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 603-611. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Gamification as a teaching method has long been known in education. While the praise for gamification in education is high and gamified-elements are said to raise students' motivation, deepen their understanding and promote their engagement (Garcia-Iruela et al., 2021; Korn, et al., 2022; Tappe & Gennat, 2023), the empiric evidence of such claims appears to be low. Especially in German VET (Metz & Becker 2022) more research is needed to identify the effects gamification has on students (Sailer & Homner, 2019, p. 78) as well as the mechanics that constitute successful gamification (Metz & Becker, 2022).

To address this goal, we have designed a concept to add game-mechanics to our newly developed training programme, the Certified Occupational Specialist for Electronics Mobility[1] (BS), which takes place in the context of "UpTrain", a funding programme of the German Federal Ministry of Education and Research as part of the InnoVET programme[2]. Our focus is to examine the effects of gamification on students in advanced training by synthesizing empirical evidence and theoretical underpinnings. As gamification can easily be added to educational programmes due to various parallels between the educational system and games (Tappe & Gennat, 2023) we proceeded to add typical elements of gamification to the programme, aiming to integrate sustainable education practices. During the initial trial of the programme, students whose recent teaching experience was in VET, struggled with the unfamiliar structure of advanced training, emphasizing the influence of their accustomed vocational-school context. Active cooperation and follow-up work were unfamiliar, leading to infrequent notetaking and limited intrinsic motivation for exam preparation.

In the following, gamified elements used in the programme are portrayed and their effects on motivation and engagement are analysed by use of various methods of evaluation. This paper thus provides insights into the challenges faced by students in advanced training and the feasibility of gamification, further emphasizing the need for further research in this evolving field.

2. Methods

This section outlines the systematic approach used to provide a proof of concept (POC) for gamification feasibility in advanced training. The implementation of our training programme, along with diverse data collection methods, forms the framework to examine the effects and acceptance of gamification among students.

[1] Original German title: „Geprüfter Berufsspezialist / Geprüfte Berufsspezialistin für Elektronik Mobilität (IHK)"

[2] For more information on InnoVET UpTrain and its objectives please refer to: https://www.inno-vet.de/innovet/de/die-projekte/alle-projekte-von-a-bis-z/uptrain-triale-weiterbildung.html

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2.1. UpTrain

"UpTrain" is a project funded under the InnoVET guideline of the German Federal Ministry of Education and Research[3], focused on transforming professional training in the mobility industry by connecting transport companies, universities, and industry to enhance industrial-technical skills through two new occupational profiles: The Certified Occupational Specialist for Electronics Mobility and the Master Professional in Technological Innovation Strategies. The concept presented here refers to the advanced training programme Certified Occupational Specialist for Electronics Mobility (BS), which the project tests twice during a period of four years (2020-2024). We will call the two iterations BS1 and BS2. UpTrain helps to prepare the public transport sector for the future by introducing new training programmes and qualification concepts, thus enhancing the appeal of training opportunities while promoting sustainability in transportation.

2.2. Sample

Our sample comprises twenty male students, aged between 22 and 54 years, with an average age of 30.6 years. All students are enrolled in the Certified Occupational Specialist for Electronics Mobility training program while employed. They represent ten different public transport companies in Germany and share backgrounds as trained electricians or mechatronics technicians. Among them, two have prior advanced training experience. Although they work in various areas within their companies, all operate within a workshop environment. Most have limited exposure to digital tools in their daily work, making this program their introduction to blended-learning concepts and learning management systems.

2.3. Design

The previously mentioned challenges for advanced training students prompted the addition of gamification mechanics to the training content, aiming to create a less tedious and more enjoyable learning environment. We thus developed a concept for the gamification of "BS2", the Rallye "UpGefahren"[4]. We introduced game-mechanics as explained in Table 1:

[3] c.f. https://www.inno-vet.de/innovet/de/was-ist-innovet/was-ist-innovet.html

[4] A portmanteau of the German words for "departed" ("abgefahren") / "whacky" ("abgefahren") and the projectname "UpTrain"

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1 – Game-mechanics used for "UpGefahren"

Element	Explanation
Teams	The elective modules compete against each other in teams: Team Bus "Team Bus", Team Rail "Team Schiene", Team Control & Safety Engineering "Team L&S".
Avatars	During orientation-week students designed and named their team's avatar: Team Bus as "Kasalla", Team Rail as "Beertrain Ultras", and Team L&S as "Die Signalraketen ". We digitalised the avatars and use them in leaderboard-animations following each challenge.
Challenges	Challenges take place either digitally or in-person, depending on what the curriculum allows. Challenges relate to the theme of the training week.[5]
Points	For continuous suspense, the number of points to be won increases each challenge (i.e. Ch.1 = 1 point, Ch.2 = 2 points, etc.).
Levels / "Stages"	The eleven stages of the Rallye align with the eleven teaching weeks of the programme. Each week introduces a new challenge.
Storytelling / Characters	The fictitious guides "Paula and Tobi" have their say at various points of the Rallye, introducing the newest challenge, announcing leaderboard-updates, etc.
Learning Experience Platform (LXP)	A specifically established learning-path, the "Roadbook", hosts information about teams, challenges, and the outcomes of past challenges.

Source: Own elaboration

2.4. Methodology

We chose three different methods of collecting information on the effects of gamification in "BS2":

- Two evaluations ("MZP1": 15.10.23 and "MZP2": 23.02.24) where the students receive access to an online questionnaire. Both evaluations are non-obligatory and anonymous. Four out of 66 question-items refer to "UpGefahren". Additionally, participants were asked to assign grades to the overall programme, where a grade of 1=very good, 2=good, 3=satisfactory, 4=sufficient, 5=poor, 6=deficient.
- A "Teaching Analysis Poll" (TAP), which had to be conducted in an online meeting due to COVID-19-related issues. Students answered questions in several stages: as a single person, in a group of 3-5 and together as a group. Subsequently, they discussed and voted on what answers were officially to be considered by the organisers of the programme.

[5] c.f. https://platform.coveseed.eu/groups/good-practice-uptrain/ for more information on the individual challenges.

2024, Editorial Universitat Politècnica de València BY-NC-SA

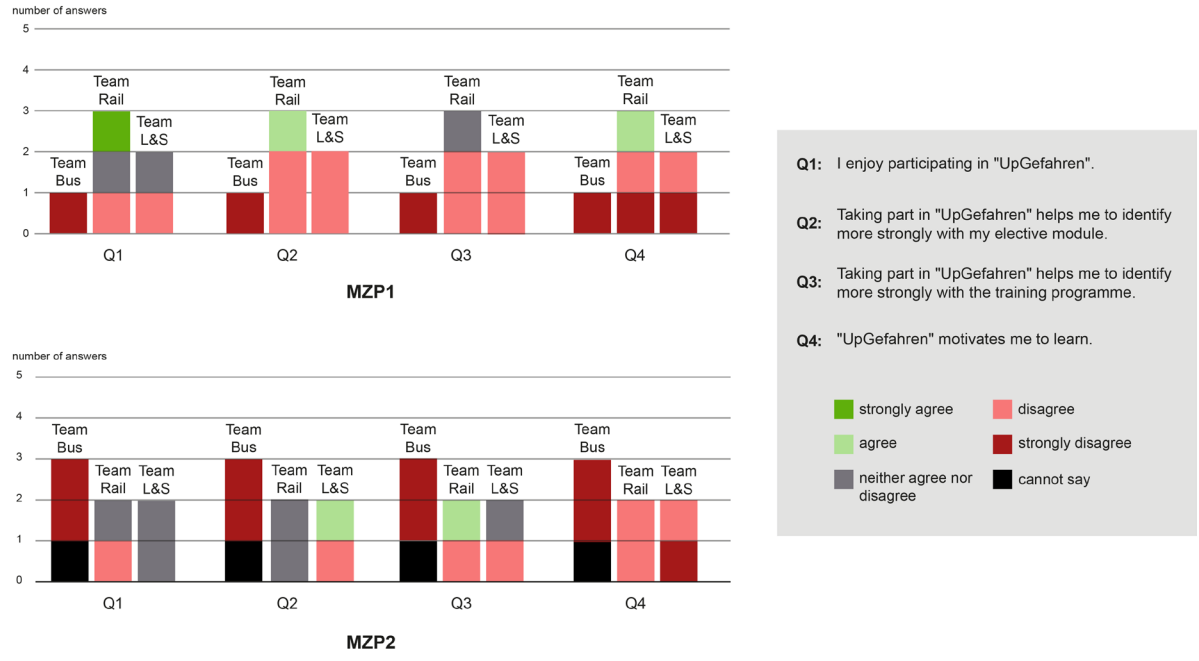
- The organising-team keeps in close contact with each other to exchange information about the status of the Rallye and the mood of the students. This paper considers discussions of the learning-atmosphere.

3. Results

3.1. Main evaluations

Nine out of twenty students participated, however two left the questionnaire unanswered, thus the seven remaining answers have been considered. Even though responses to the questionnaire (Fig.1 – question item 1) show that few students enjoyed participating in "UpGefahren", students actively enquired about the next challenge when meeting instructors in-person. Disappointment set in when it did not take place that day (cf. Table 2). When asked to grade the overall training programme, Team Bus consistently rated it as "poor," Team Rail's ratings ranged from "good" to "satisfactory," and Team L&S rated it as "satisfactory" to "sufficient." Figure 1 and the participants' grades show that Team Bus displayed a higher dissatisfaction than members of other teams, whereas Team Rail showed more mixed responses compared to the other teams. Additionally, there were no significant changes in responses between MZP1 and MZP2, indicating that perceptions of "UpGefahren" and the training programme remained relatively stable over time for each team.

Fig. 1 – Main Evaluation MZP1, MZP2



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.2. Teaching Analysis Poll

The TAP happened shortly after a challenge that had to be digitalised quickly due to COVID-19 infections of some students. As an answer to the question "What disrupts or debilitates your learning experience? What should be abandoned?" two students from Team Bus and L&S mentioned "UpGefahren". Even though other students did not agree, the group mutually decided to add the responses in the official account.

3.3. Informal Feedback

This qualitative data was collected among team members during video- and telephone calls, via E-Mail and direct messages, debrief notes as well as verbal feedback from and observations of students. The data includes anecdotes as shown in Table 2:

Table 2 – Informal Feedback

Source	Feedback
Team L&S	Student resolved to signing his name in an E-Mail, followed by his Rallye-team affiliation.
Team Rail	The team produced a 3D-printed model of their Rallye-avatar, which they presented proudly.
Team Bus	The team ceased participation in the challenges, falling far behind in points. One team-member noted a lack of transparency regarding the challenges and their associated learning objectives.
Team L&S	Instructors were approached by disappointed students when "no games" were scheduled.

Source: Own elaboration

4. Discussion

In this section, we delve into the implications and significance of our POC examining the feasibility of gamification in advanced training and sustainable education by analysing the results of our evaluations. We identified several behaviours that became particularly apparent in the Rallye's effect on students.

4.1 Participation & Fun

Over time it became clear that not all students participated with the same vigour (cf. Table 2). In-classroom learning during advanced training can be perceived as tedious to students who are used to work in practical environments (Jayalath & Esichaikul, 2020; Wingendorf & Bombelka, 2023). As this was the case with BS1, we intended to utilise "UpGefahren" as a counteractive measure during our second trial. However, certain game-mechanics can cause the opposite when not correctly linked to the students' needs (Garcia-Iruela et al, 2021; Spies, 2022). Further, different contexts as well as individuals within the target audience have

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

different responses to methods such as gamification (Barradas & Lencastre, 2021). We had made participating "UpGefahren" non-obligatory, to pre-empt negative responses by students.

4.2 Identification with the elective module

During orientation week "UpGefahren" introduced a competitive element that enhanced team-dynamics, as we observed students' enthusiastic approach to their first challenge (cf. Table 1): Students displayed a shift towards a more relaxed attitude, reflected in the team designs and names. The challenge aimed to address adult learning obstacles through light-hearted competition, as suggested by Dahalan et al. (2023), Korn, et al. (2022) and Sailer & Homner (2019). Team Rail displayed considerable signs of motivation and identification with their team by autonomously creating a 3D model of their avatar. Additionally, Team L&S displayed a similar attitude by signing E-Mails with their team-affiliation (cf. Table 2). However, considering the (few) responses to the question-item "Taking part in "UpGefahren" helps me to identify more strongly with my elective module" (cf. Fig. 1), there is no apparent consensus in the students' attitude towards "UpGefahren" which indicates a partial discrepancy between literature and our experiences.

4.3 Identification with the training programme

While experiences of instructors and informal feedback of students led to believe that the Rallye helped students to identify themselves with their elective module, it does not seem to support the identification with the training programme (cf. Fig. 1), as the corresponding question-item (3) resulted in no agreement. This outcome could be attributed to a lack of game-mechanics that align intrinsic and extrinsic motivation and thus strengthen identification as described by Garcia-Iruela et al. (2021). In this case, the competition may have shifted the students' focus away from engaging with the learning content toward solely achieving small victories. Overall, there seems to be a correlation between the grades assigned to the training programme and the game evaluation responses, with consistent negative sentiments expressed by all teams. Participant grades indicate dissatisfaction with the programme, possibly influences by factors like a lack of practise-oriented teaching units.

4.4 Motivation to learn

The gamification-concept of "UpGefahren" includes several typical gamification mechanics (cf. Table 1) that have been proven to foster motivation in students when utilised in a learning context (Jayalath & Esichaikul, 2020; Lefers & Birkenkrahe, 2017; Wingendorf & Bombelka, 2023). However, in our evaluation few students agreed with the statement ""UpGefahren" motivates me to learn." (cf. Fig. 1 – question item 4). Further, Team Bus pointing out a lack of transparency behind the choice of gamification-mechanics shows that more work needs to

BY-NC-SA 2024, Editorial Universitat Politècnica de València

be done explaining and highlighting expected learning outcomes and subtle effects of gamification to learners. This correlates with Garcia-Iruela et al. (2021) statement that intrinsic and extrinsic motivation need to be aligned to "the commitment and motivation of students to actively participate". The fact that a substantial challenge had to be digitalised last-minute might have shifted the group's attitude towards a more negative one.

5. Conclusion/ Recommendation

In conclusion, the findings of this paper offer valuable insights into the feasibility of gamification in advanced training, specifically in the context of the BS2-trial. "UpGefahren" has yielded mixed results from students as in-person experiences with the group differ vastly from their submitted feedback. With a group of 20 students, the sparse participation in non-obligatory questionnaires means the evaluation results lack representativeness. Nonetheless, they offer valuable qualitative insights with concrete examples, allowing for assessment of gamification efficacy in this specific instance. Drawing broader conclusions on gamification's general effectiveness is speculative due to factors like group dynamics, educational backgrounds, digital media experience, and expertise. Mentors regularly reported a positive atmosphere among the students and positive feedback towards the Rallye. As we reflect on the results, despite the negative responses that were mainly communicated via questionnaire, we conclude that "UpGefahren" has been received as an overall positive experience for the students. It is evident that students did display enjoyment in friendly competition given the opportunity to break out of typical in-classroom experiences. Various comments and inside jokes demonstrate that added game-mechanics made the otherwise tedious and challenging experience of advanced training more enjoyable. Nevertheless, critical voices that have emerged during "UpGefahren" need to be considered. Hence, several implications emerge for us and other institutions that are interested in applying game-mechanics to their (advanced) training programmes: Mainly, we aim to make the expected learning objectives that are related to the challenges clearer to provide students with more obvious reasons to participate not only in the Rallye but also in learning. We also plan to further streamline and possibly minimise digital challenges, as we could observe decreased motivation due to the missing social component. It remains to be seen if the examination results point towards a deepened learning experience possibly being enhanced by gamification.

Further research might focus on a direct link between specific game-mechanics and expected learning outcomes towards achieved learning outcomes. Since this proof of concept cannot serve as proper empirical evidence for the feasibility of gamification in advanced training, more extensive research is needed. Considering the importance of sustainable education, future studies could investigate the long-term effects of gamification on student engagement and retention in advanced training programmes.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

UpTrain is funded by the German Federal Ministry of Education and Research as part of the InnoVET programme - VDV-Akademie e.V. (21IV009A), Hochschule Bochum (21IV009F).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Barradas, R., & Lencastre, J. A. (2021). Gamification and game-based learning: strategies to promote positive competitiveness in the teaching and learning processes. *Gaming in Action*, 51-75.

Dahalan, F., Alias, N., & Shaharom, M. S. N. (2023). Gamification and Game Based Learning for Vocational Education and Training: A Systematic Literature review. *Education and Information Technologies*. https://doi.org/10.1007/s10639-022-11548-w

Garcia-Iruela, M., Pérez-Marín, D., & Connolly, C. (2021). Analysis of three methodological approaches in the use of gamification in vocational training. *Information*, 12(8), 300. https://doi.org/10.3390/info12080300

Jayalath, J., & Esichaikul, V. (2020). Gamification to enhance motivation and engagement in blended eLearning for technical and vocational education and training. *Technology, Knowledge, and Learning*, 27(1), 91–118. https://doi.org/10.1007/s10758-020-09466-2

Korn, O., Schulz, A., & Hagley, B. J. (2022). Gamification: Grundlagen, Methoden und Anwendungsbeispiele. *Digitale Lernwelten – Serious Games und Gamification,* 43–63. https://doi.org/10.1007/978-3-658-35059-8_4

Lefers, B., & Birkenkrahe, M. (2017). Was ist der didaktische Mehrwert von Gamification? Reflexion statt Regression. *Spielräume: Facetten von Gamification in Unternehmen und Weiterbildung*.

Metz, M., & Becker, W. (2022). Zukünftige Entwicklungsperspektiven von Serious Games und Gamification in der beruflichen Bildung. *Digitale Lernwelten – Serious Games und Gamification*, 309–314. https://doi.org/10.1007/978-3-658-35059-8_18

Sailer, M., & Homner, L. (2019). The Gamification of Learning: a Meta-analysis. *Educational Psychology Review*, 32(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Spies, B. (2022). Entwicklung von Serious Games aus lerntheoretischer, mediendidaktischer und medienpsychologischer Perspektive. *Digitale Lernwelten – Serious Games und Gamification,* 27–41. https://doi.org/10.1007/978-3-658-35059-8_3

Tappe, E., & Gennat, M. (2023). Spielend Lernen? Ein kritischer Vergleich zwischen Lernmöglichkeiten in digitalen Spielen, Serious Games und Gamification. *Game Journalisus,* 193-207. https://doi.org/10.1007/978-3-658-42616-3

Wingendorf, M., & Bombelka, A. (2023). Gamification zur Steigerung der Motivation von Teilnehmenden mehrstufiger Aus- und Weiterbildungsmaßnahmen. *Banking & Innovation 2022/2023*, 165–179. https://doi.org/10.1007/978-3-658-39388-5_10

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Implementation of adaptive learning in higher mathematics at Riga Technical University

Inta Volodko and Sarmite Cernajeva

Institute of Applied Mathematics, Riga Technical University, Latvia

Abstract

Adaptive learning is one of the newest approaches in the learning process, which correlates most positively with the performance of pupils and students. It empowers all students to succeed by redesigning the learning process to best support students, offering pre-teaching where needed. The purpose of the article is to investigate how adaptive training is implemented in the studies of mathematics at Riga Technical University (RTU) and what results it gives. RTU students who have weak knowledge of mathematics are offered additional lessons in mathematics. The article analyses how these classes help students achieve good results in mathematics. In adaptive teaching, lecturers must understand that students learn at different paces. To help students who have a slower learning pace, the authors of the article have created video lectures that are available to all students of RTU and are a good support for students in learning mathematics. Student self-assessment and feedback are also important in the adaptive learning approach. For this purpose, our Institute has prepared online tests, as well as face-to-face tests, the results of which form part of the semester evaluation. The article examines how the performance of these tests contributes to students' mathematical knowledge and correlates with the semester grade. As a result, we can conclude that adaptive teaching gives all students the opportunity to succeed, as long as they devote enough time and effort to their studies.

Keywords: adaptive learning; teaching mathematics; video lectures; online tests.

How to cite: Volodko, I. and Cernajeva, S. (2024) Implementation of adaptive learning in higher mathematics at Riga Technical University. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 612-620. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Sustainable development is based on three pillars: economy, environment and society. Our students are the part of society that will move our country towards sustainable development. These are the future economists who will contribute to the economic growth of the country; the future architects and builders who will build sustainable cities; future chemical technologists who will invent new, environmentally friendly materials; future energy engineers who will find new, more profitable energy sources. Mathematics is the basis of training for all engineering specialties, therefore a quality mathematical education is essential. In addition, one of the goals of sustainable development is quality education, so it is important to introduce new methods and means in higher education.

Adaptive learning is one of the newest and most modern approaches to the learning process, which takes into account the strengths and weaknesses of all students. Recently, there has been a lot of talk about this type of training on the Internet, and special software has even been developed (Cavanagh et al., 2020, Kurt, 2021, McGuire, 2021). Unlike the differentiated approach, which focuses on individual students, adaptive teaching focuses on the entire group of students. It allows all students to succeed, but not in comparison to other students in the group, but rather in comparison to their former self, that is, each student has the opportunity to progress.

Several articles in the literature (Cavanagh et al., 2020, Mirata and Bergamin, 2019, Mirata et al., 2020, Mirata and Bergamin, 2023) emphasize that although adaptive learning is becoming a promising and innovative method, its implementation in higher education is still low. The mentioned articles discuss the challenges that prevent higher education institutions from implementing the concepts of adaptive training, as well as provide recommendations for the effective implementation of the adaptive training. However, the implementation of the adaptive training has increased in recent years. Learning outcomes in courses with the adaptive learning are better than in courses without it (Contrino et al., 2024). The results show that the adaptive learning is a good strategy for teaching undergraduate courses.

Adaptive teaching requires teaching staff to:

- Learn to choose the right approach, which allows to effectively learn the learning material in the specific topic;
- Understand that various factors can hinder students' ability to learn, and help to overcome them;
- Promote the intellectual development of both those students who have good skills and those who have difficulties in learning the subject;
- Rethink study plans, their strategic implementation, continuously improve the learning process and ensure equal opportunities for all students.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

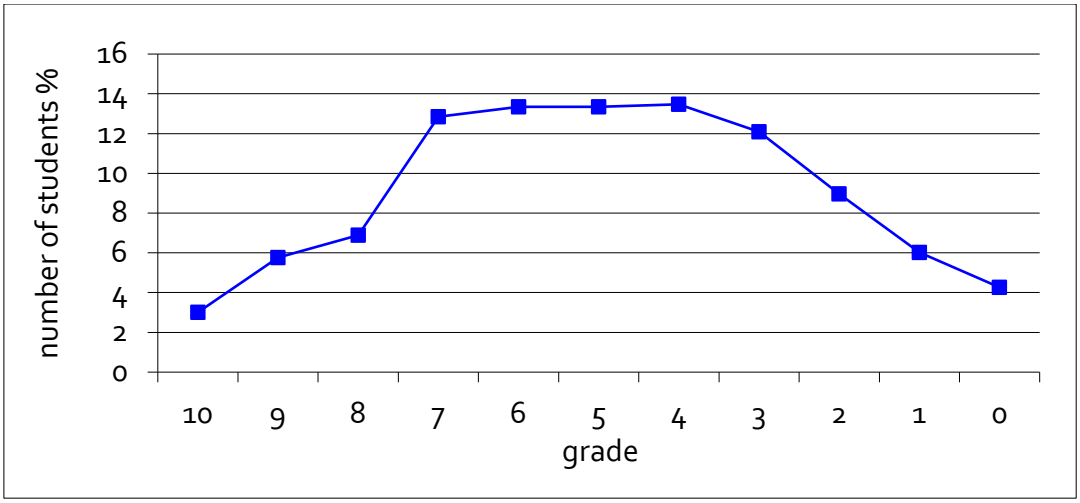
2. Practical application of adaptive training methods

2.1 Additional classes

All 1st-year students of Riga Technical University are given a test of elementary mathematics knowledge in the first mathematics lesson. The test contains 10 simple tasks on the following topics: operations with fractions, calculating the value of a function, solving the simplest equations and inequalities, properties of exponents and logarithms, calculating percentages, calculating the area of a plane figure. For each correctly solved task, the rating is 1 grade. Unfortunately, the test results show that a large part of the students admitted to our University have not learned Elementary Mathematics at a sufficient level to successfully study Higher Mathematics. At the beginning of the school year 2023/24, 1596 students took the test and a third of them (31%) received a failing grade (less than grade 4). Figure 1 shows the distribution of grades obtained in the test, from which we can see that, when entering University, students mostly have average knowledge of elementary mathematics, the majority of students scored grades 4 - 7.

Even bigger problems are caused by the fact that, starting from 2020, the form and content of secondary education in Latvia has changed. Now, in secondary schools, students have the opportunity to learn the content of the subject at 3 levels: general, optimal and the advanced level. Students who have studied mathematics at the optimal or advanced level are admitted to RTU. The problem is that the classes are held together for students, without separating them according to the level of mathematics they have learned at school. Students who studied mathematics at the advanced level at school have already mastered part of the subject of Higher Mathematics, while those who chose the optimal level of mathematics at school do not have such knowledge.

Fig.1. – Distribution of grades in elementary mathematics test

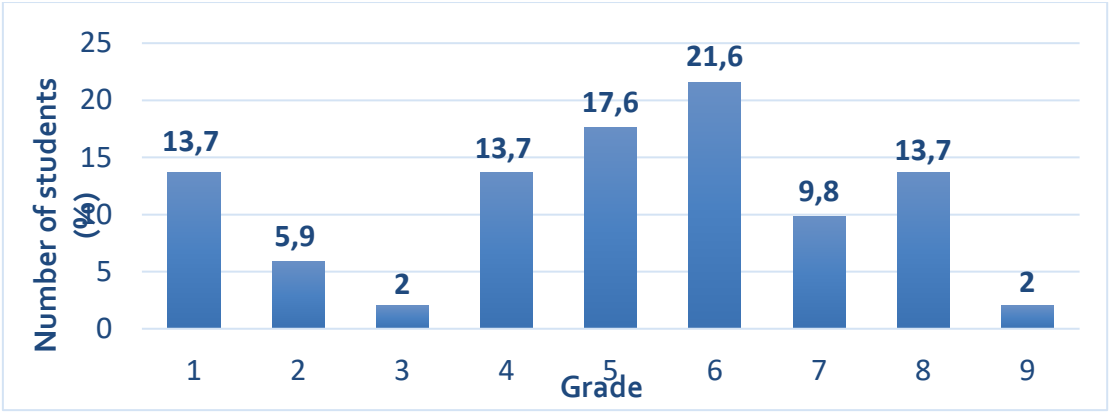


Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

Students with weak knowledge of elementary mathematics and those who learned mathematics at the optimal level at school are offered an additional course in mathematics. This course is compulsory for students who scored less than 5 points in the Elementary Mathematics test, for other students attendance of the course is voluntary. As experience shows, most students are happy to attend these classes, and many attend voluntarily. The results of the student mathematics exam show the usefulness of this course: 78.4% of the students for whom the course was compulsory passed the exam, and a large number of them showed good and excellent results.

Fig.2. – Mathematics exam grades for students for whom the supplementary course was compulsory



Source: Own elaboration

As Figure 2 shows, almost half of these students (47.1%) got a grade higher than the average (6-9). In addition, out of 21.6% of unsuccessful students, only 2 students were those who regularly attended mathematics supplementary course. Therefore, we can conclude that the provision of additional teaching gives opportunities to succeed even for students with initially weak knowledge of mathematics.

2.2 Video lectures - help for students

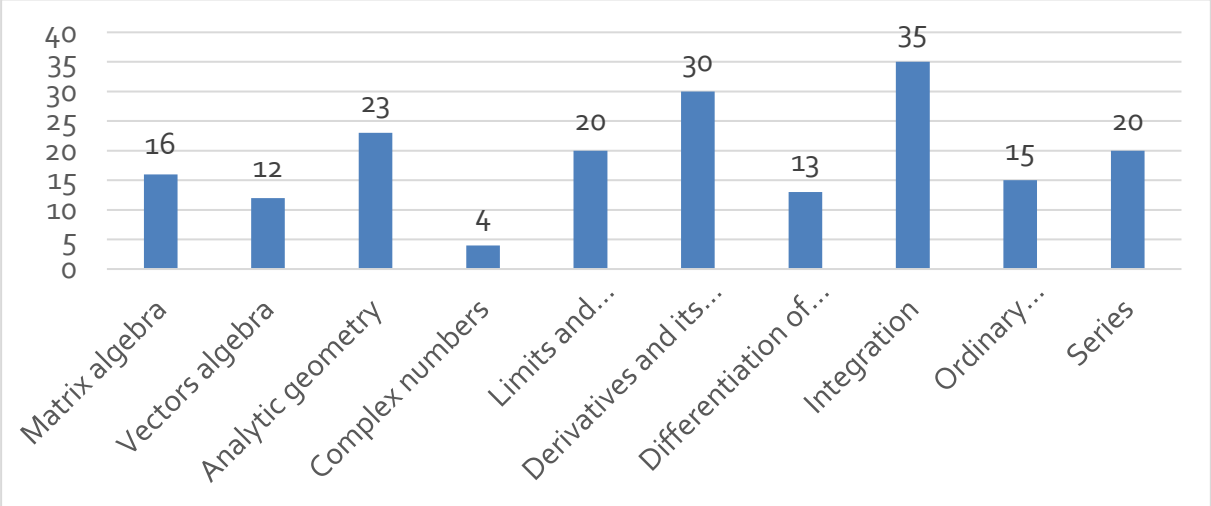
Taking into account the fact that students learn at different paces, and many students need support in learning Higher Mathematics, the authors of the article in cooperation with RTU University Media Center created video lectures on the entire basic course of mathematics. They are available for RTU students on YouTube. Video lectures were filmed by a professional cameraman and were processed with computer equipment, introducing attractive elements. When creating these video lectures, it was taken into account that the interest of students fades quickly, therefore all video lectures are short - 3 to 15 minutes long, only some of them last around 30 minutes. A total of 183 video lectures were filmed: 118 of them on the subjects of the first semester, 65 on the subjects of the second semester. These include the following mathematics sections: Matrix algebra, Vectors, Analytic geometry, Complex numbers, Limits and continuity, Derivatives of functions of one variable and its applications, Differentiation of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

functions of several variables, Integration, Ordinary differential equations, Series. There are 201 subscribers for video lectures. Although the last video lectures were completed less than a year ago, they have a total of 66292 views.

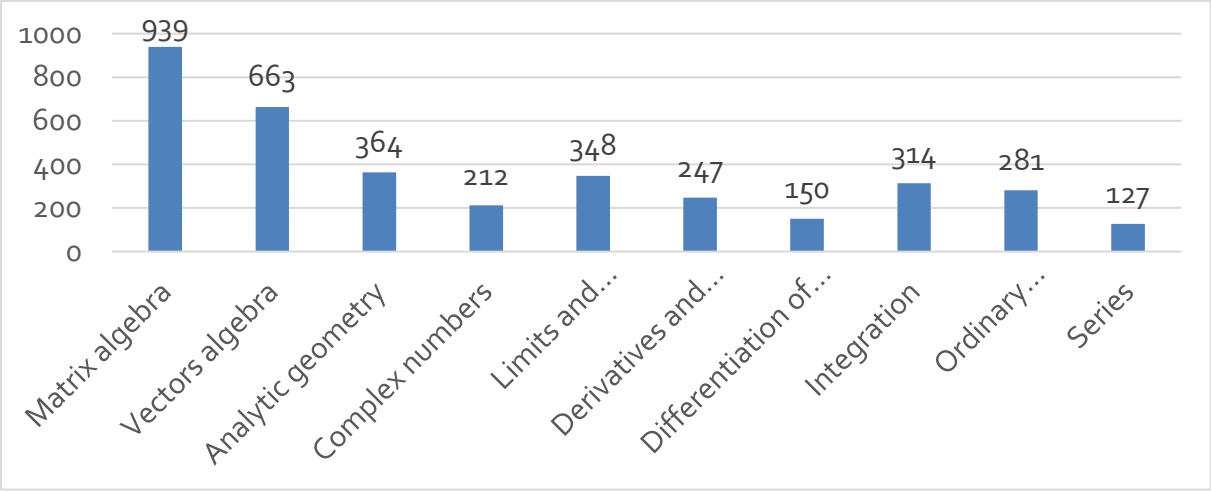
Figure 3 shows the number of video lectures in each of the corresponding sections, while Figure 4 shows the average number of views of video lectures by the corresponding sections.

Fig.3. – Number of video lectures in relevant mathematics sections



Source: Own elaboration

Fig.4. – The average number of video lecture views in the corresponding mathematics sections



Source: Own elaboration

The first video lectures have the most views, because it is something new for students and they are interested. Over time, the interest of students decreases a little, but the least views are in those topics where students do not have a test (these are Complex numbers and

2024, Editorial Universitat Politècnica de València BY-NC-SA

Differentiation of functions of several variables). There are also fewer views on the 2nd semester topics, because these video lectures were only available to students for one year, unlike the 1st semester lectures, which were used for 2 years.

Students enjoy watching these video lectures and appreciate them highly. Here are some student statements:

- Video lectures can be watched at any time and place, because nowadays everyone has mobile phones and access to the Internet;
- You can stop the video lecture at any moment and continue watching when you need;
- You can watch it repeatedly as long as you understand the topic;
- The part that is known can be fast-forwarded;
- These video lectures are unique because they are the only mathematics video lectures in Latvian.

Video lectures are very helpful for students who are slower learners and cannot follow the material during the lecture. They allow students to learn the course at a time and place more convenient for them, as well as by choosing a learning pace that suits them. They are also a good helper for those who miss the lecture due to illness or other reasons.

On the other hand, the statistics of video lectures allow teaching staff to track which topics are better understood by students and which ones cause difficulties. Statistics show that in the most difficult topics, the same student views the video lectures several times, and stops it several times for a few minutes. If there are many such students, it indicates that the lecturer should devote more attention to a particular topic.

2.3 Tests - self-testing and feedback

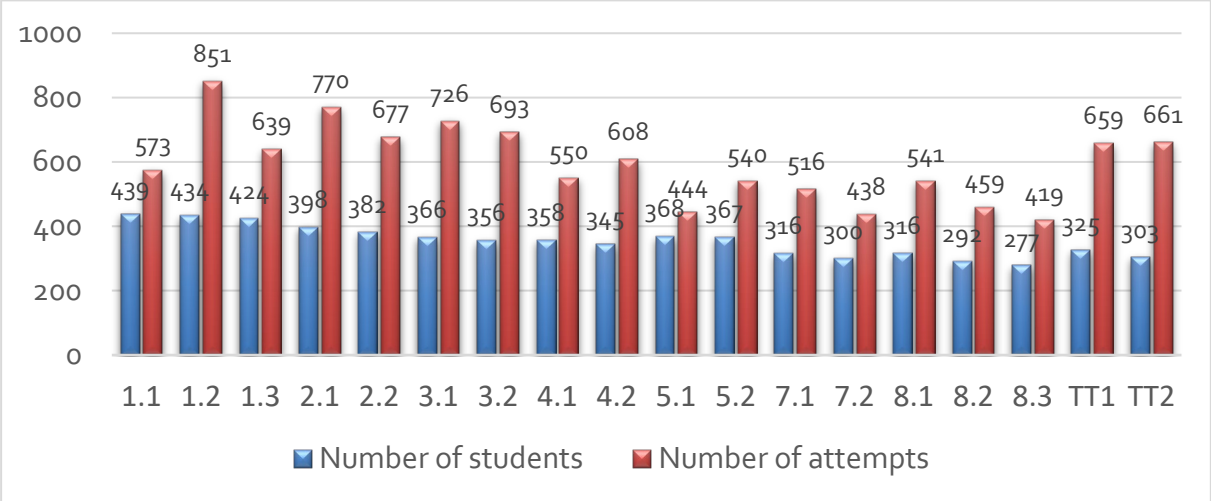
In adaptive teaching, the development of students' skills, including self-testing and feedback, is of great importance. For this purpose, lecturers of Institute of Applied Mathematics has developed tests: both online tests and face-to-face tests. In order to motivate students to work during the semester, test results make up 50% of the semester evaluation: 35% of them are the results of face-to-face tests, 10% - the results of online task tests and homework, 5% - the results of online theory tests. The remaining 50% of the assessment is given by the exam. During the 1st semester, students must complete 6 face-to-face tests, 16 online assignment tests, 4 homeworks and 2 theory tests; in the 2nd semester – 5 face-to-face tests, 3 online tests, 3 homeworks and 2 theory tests.

After performing the face-to-face test, the student receives not only the test evaluation, but also specific feedback, he has the opportunity to question the evaluation and defend his opinion in a discussion with the teaching staff, as well as to correct the result by performing the test again (of course, the test tasks are changed).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

All online task tests are short: 2-5 tasks. They are given 2 hours to complete and the test can be repeated 3 times. The base of tasks is quite large, therefore, the probability that you will hit the same tasks when taking the test again is very small. In all exercises, the answer is a number that the student must write. If a student completes the test several times, the best attempt is taken as the final result.

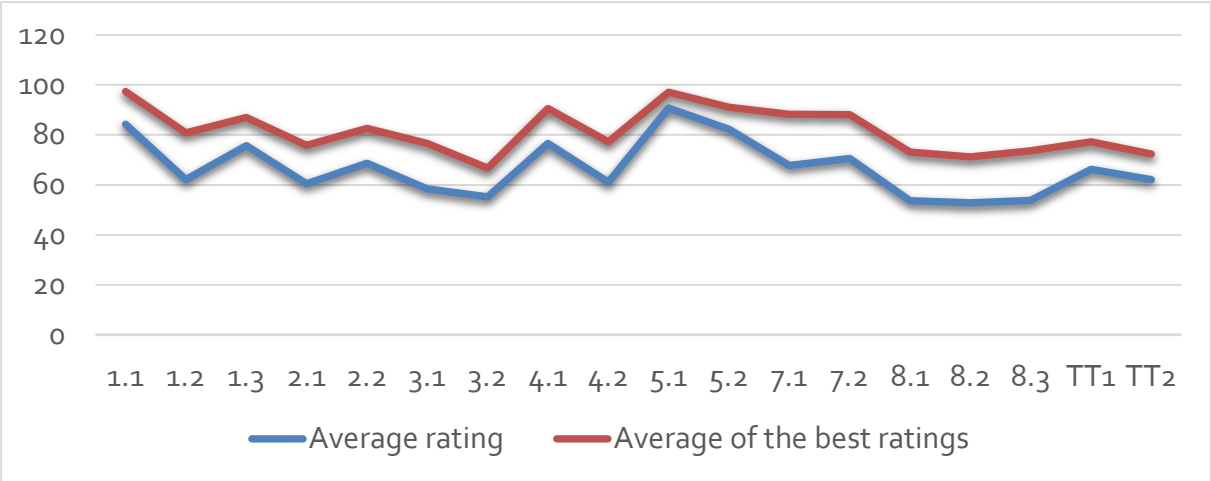
Fig.5. – Number of students taking the test and number of attempts



Source: Own elaboration

The following data are taken from the 1st semester of this academic year 2023/24. 480 students are registered in the course. Figure 5 shows the number of students who took the test and the number of attempts. Similar to video lectures, the number of students taking the test also decreases towards the end of the semester. There are two reasons for this: 1) some students drop out during the semester; 2) by the end of the semester, the students are exhausted and their commitment to complete all the work has decreased.

Fig.6. – Test results: average score of all attempts and average score of best attempts



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

Figure 6 shows the statistics of the results obtained in the test: the blue line – the average rating of all attempts, the orange line – the average rating of the best attempts. The statistics of test scores allow the teaching staff to determine which topics are causing more problems for students (where the results are worse) and to pay more attention to these topics.

As experience shows, students prefer online tests to handwritten homework. However, tests and homework are necessary for the student to properly prepare for tests and exams. Evaluating the statistics of the results of student tests and final evaluations, we can conclude that correctly composed online tests mostly give an objective evaluation and correlate well with the results of the work done in the auditorium. Online tests also greatly facilitate the work of teaching staff, especially in subjects with many tests and many students.

3. Conclusions

1. Many students admitted to the university do not have sufficient prior knowledge to successfully study at the university. Additional classes help level the students' knowledge and allow students with weak knowledge of Elementary Mathematics to achieve good results.

2. In addition to classroom lectures, video lectures are a good assistant for lecturers. They allow students to learn the course at a time and place convenient for them, as well as by choosing a learning pace that suits them. Video lectures are a good substitute for a face-to-face lecture for those who miss a lecture due to illness or other reasons.

3. Tests serve well as self-testing of students' knowledge and also as feedback: both classroom and online tests. The statistics of test results show that taking tests regularly helps students prepare for face-to-face tests - tests and exams.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

No known competing financial interests or personal relationships have influenced the work reported in this paper.

References

Cavanagh, T., Chen, B., Lahcen, R. A. M., & Paradiso, J. (2020). Constructing a Design Framework and Pedagogical Approach for Adaptive Learning in Higher Education: A Practitioner's Perspective. *The International Review of Research in Open and Distributed Learning*, *21*(1), 173–197. https://doi.org/10.19173/irrodl.v21i1.4557

Contrino, M.F., Reyes-Millán, M., Vázquez-Villegas, P., & Membrillo-Hernandez, J. (2024). Using an adaptive learning tool to improve student performance and satisfaction

BY-NC-SA 2024, Editorial Universitat Politècnica de València

in online and face-to-face education for a more personalized approach. *Smart Learning Environments.* 11, 6. https://doi.org/10.1186/s40561-024-00292-y

Kurt, S. (2021). Adaptive learning: What is it, what are its benefits and how does it work? *Educational Technology*. https://educationaltechnology.net/adaptive-learning-what-is-it-what-are-its-benefits-and-how-does-it-work/

McGuire, R. (2021). What is adaptive learning and how does it work to promote equity in higher education. *Every Learner Everywhere.* https://www.everylearneverywhere.org/blog/what-is-adaptive-learning-and-how-does-it-work-to-promote-equity-in-higher-education/

Mirata, V., Bergamin, P. (2019). Developing an implementation framework for adaptive learning: A case study approach. *Proceedings of the European Conference on e-Learning,* Vol. 2019-November, 668–673. https://doi.org/10.34190/EEL.19.024

Mirata, V., Bergamin, P. (2023). Role of organisational readiness and stakeholder acceptance: an implementation framework of adaptive learning for higher education. *Educational Technology Research and Development,* 71, 1567–1593. https://doi.org/10.1007/s11423-023-10248-7

Mirata, V., Hirt, F., Bergamin, P., & Van der Westhuizen, C. (2020). Challenges and contexts in establishing adaptive learning in higher education: findings from a Delphi study. *International Journal of Educational Technology in Higher Education,* 17, 32. https://doi.org/10.1186/s41239-020-00209-y

2024, Editorial Universitat Politècnica de València BY-NC-SA

Health Screening & Physical Education Surveillance for Different Types of Students

Florin Moștoflei[123]

[1] Biochemistry and Training Technology Dept., The National Institute for Sport Research, Romania
[2] former associated Lecturer at Physical Education and Sport Dept., The Bucharest University of Economic Studies, Romania
[3] former invited Specialist, The Police Academy "Alexandru Ioan Cuza", Romania

Abstract

This study presents three different types of students (top athletes, active sportsmen or regular youth) following a similar type of surveillance, with similar equipment, conducted by the same personnel, during the same period of the year, but in different environments. The research started right before the COVID-19 pandemic with no social restriction, and part of the results could be implemented years after that, as a surveillance program during physical activity. Even though the hypothesis was not confirmed, the objectives of the research supported the metabolic integrity of the students sustained by informational feedback during the classes. Such kind of program may also be implemented in many working environments with mutual benefits for both the employing entities, and the employees.

Keywords: Forced Vital Capacity; heart rate diagram; maximal oxygen uptake, Relative Force Index

How to cite: Moștoflei, F. (2024) Health Screening & Physical Education Surveillance for Different Types of StudentsIn proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 621-629. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

This study focuses above subjects/students organized in three different groups. This non-invasive approach tries to reveal some particular aspects regarding HR diagrams, Forced Vital Capacity (FVC), maximal oxygen uptake (VO2max) and other items that followed, independently one from other, a specific surveillance process. The physical education (P.E.) programmes for two of the groups (A&B) were adapted to each unit's specificity and infrastructure: there were different by content. However, there were sufficient conditions for data acquisition sustained by various sports facilities and a mobile gear, in order to fulfil the research objectives.

A couple of aspects supported the work (beside voluntary students' involvement and official agreement on behalf of each P.E. Department):

- The experience of the leading-researcher with his double-qualified status as a sport scientist and associated P.E. lecturer / invited specialist with already mentioned institutions; A similar surveillance programme had previously been conducted and completed without any kind of interference (Moștoflei, F., 2017 & 2018).
- The licensed-type equipment used during data collection (acknowledgement #1).

2. Assumption

The study starts form the premise that a higher resting heart rate (RHR) can be related with lower physical fitness while a lower RHR value can be associated with greater physical fitness (Solan, M. 2021). The researcher/teacher presumed that all the surveyed subjects were fit enough for basic physical effort during sport classes. Additionally, every volunteer / subject admitted that were interested to take part at the programme; every medical-exempted student did not receive 2 credits for P.E. discipline.

3. Purpose

Any irregularity (HR diagrams) spotted during observation process rose additional attention on several identified subjects.

4. Objectives

4.1: Comparative study of Orthostatic Test (OT) diagrams between trained, regular and particular subjects/tachycardic trends;

4.2: HR diagrams association with each P.E. class typology (ex: fitness, basketball, volleyball, combat etc); a continuously improving database collection for every educational entity might be useful focusing on HR dynamics during physical effort, especially for those units that are dealing with regular students/not elite athletes;

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

5. Hypothesis

5.1 An FVC (forced vital capacity) item superior to the predicted values of 100% may find a correspondent in a VO2max superior fitness level sustained by a good RFI (≥2 relative force index / plyometric effort) - for the subjects participating in all 5 research phases. (Gr. A)

5.2 An upper than 100 b/min resting Heart Rate value (R.H.R.) during OT /sitting position may find a highly H.R. correspondent during the effort. (Gr. A & B)

6. Attendance & Data collection

Stage 1: The time table included 14 weeks attendance in first semester of AY 2018-2019 at sport facilities from The Bucharest University of Economic Studies (Gr. A), The Police Academy "Alexandru Ioan Cuza" (Gr. B) adding info (laboratory conditions) from female judoka of Sport Club Municipal Deva (Gr. C). First stage starts with approaching of any available study subjects, by filling a 6-item questionnaire. Less crowded sport facilities were preferred for suitable collective control.

Group A: 222 subjects approached, 13 weeks of surveillance (starting on 18.10.2018, last session 18.01.2019, sport facilities: sports hall, combat & aerobics rooms, fitness gym), attendance 1 per week, 75 minutes/session, 5 steps of the research; volunteers n=23 (7 female & 16 male, born: 1998)

Group B: 50 subjects approached, 7 weeks of surveillance (starting on 13.11.2018, last session 17.01.2019, sport facilities: Stadion & sports hall, combat room / specific program), attendance 2 per week/ for each (3) year of study, 90 minutes/lesson, 4 steps of the research; volunteers n=28 (24 female & 4 male, born: 1996-1972)

Group C: 7 subjects approached, 2 days of tests (starting on 07.12.2018), laboratory conditions, 2 steps of the research; volunteers n=2 (only female students, born: 1998-2000);

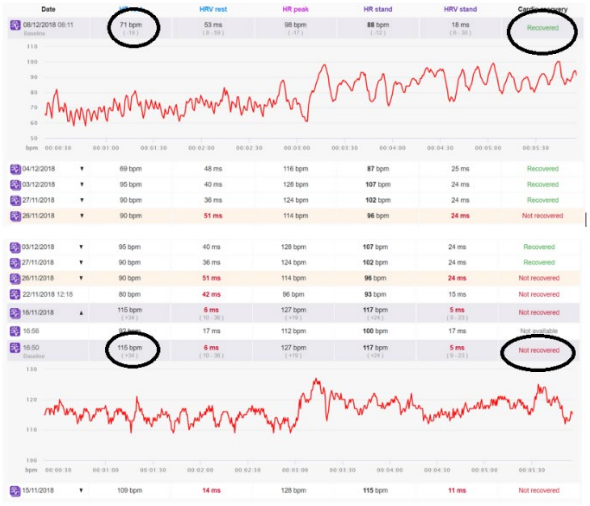
From a total of 28 volunteer-subjects in Group B, 11 declared that they were current or former active athletes. As for Group A, from a total of 23, 10 were in a similar situation (acknowledgement #2); Group C included 2 elite judokas who competed in the end of the year 2018.

Stage 2: included the data collection of body weight item (T-shirt, barefoot, minus 0.5 kg tolerance), height (metric scale) and RHR (resting heart rate beats / min) in sitting position (pulse oximeter). As for the orthostatic test (OT – 6 minutes Polar protocol) I've used an adapted procedure comprising sitting & standing position instead of lying down & standing (due to sport facilities & time restriction). A total of 14 subjects form Group B (1 test failed due to sensor manipulation) adding 2 from Group C and 19 from Group A passes the test. Six subjects (5 from Gr. A and 1 from Gr. B) developed values of RHR ≥ 100 b/min in sitting position and focused additional attention from the researcher. OT was performed in the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

beginning of physical activity and the subjects were temporary separated from the collective, without speaking to each other, and away of any disturbing factors (Figure 1).

Fig. 1 – Different OT diagrams (trained RHR 71 b/min vs untrained RHR 115 b/min) – sitting & standing



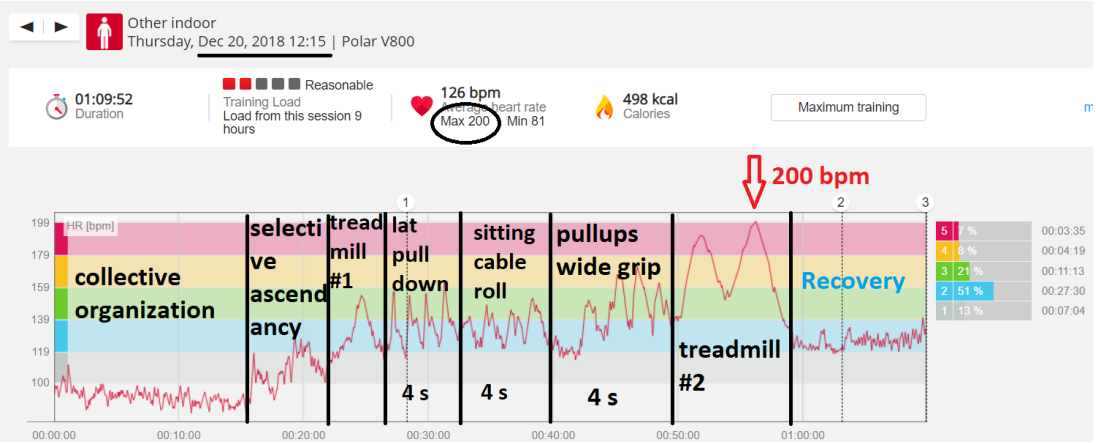
Source: flow.polar.com/progress/tests (2024)

Stage 3: In order to identify the peak of HR max for each type of activity, I've filled every time a written journal/observational protocol, after H7 sensor setting on subjects' torso. Such measure was mandatory for later interpretation of the graphics (Figure 2). The class typology followed a specific university curricula and student's involvement during the effort was totally at their disposal/control – no intervention from the researcher to push the subjects to the limit. The main reference point for HR max index was the formula 220 minus age (Robergs, R. & Landwehr, R., 2022); however, the HR graphics were downloaded post-factum (no online acquisitions providing instant feed-back / acknowledgement #3).
A total of 18 h 10'08" of effective HR surveillance of 20 subjects (17 from Gr. A and 3 from Gr. B) presented clear & partially accepted graphics including 2h 26'43" of totally unaccepted information. The transmission errors between watches and sensors were recorded mainly on combat classes or during physical exercises on the floor/mat with partner (Gr. B).

As for VO2max items, I used Polar V800 paired with H7 sensors with personal data entered for each subject. When the HRmax item was collected properly (Figure 2) the data was entered to the watch settings along with other personal information such as age, height, weight, training background, date of birth, min HR and a set by default VO2 max. At the end of Fitness tests, the device offers an estimated index of VO2max (maximal oxygen uptake) along with interpretation (fitness level: elite, very good, moderate etc - Figure 3). The Fitness-test was conducted in sitting position due to space restriction for Groups A&B, before (and not after) physical effort.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 2 – Sample of clear HR graphic with written protocol / fitness class



Source: flow.polar.com/training/analysis/3066141790 (2024) overwritten

The sequence of the tests was as following: first: OT test; second: HR max test; third: Fitness test (VO2max). For those students without FC max value extracted in real time, or with graphic error recordings, set-by-default data was inserted (based on the formula 220 minus age – symbol * Table 1). In both cases the values and interpretations were automatically *estimated* by the device.

Fig. 3 – Sample of collected VO2max values (2018)

12/12/2018 17:43	58	Elite
06/12/2018 07:53	39	Moderate
03/12/2018 ▼	46	Good
27/11/2018 17:35	36	Fair
22/11/2018 12:28	68	Elite
16/11/2018 17:02	53	Good
15/11/2018 ▲	49	Moderate
12:26	49	Moderate
08:02	34	Fair
09/11/2018 ▼	45	Moderate
08/11/2018 ▲	69	Elite
12:45	54	Good
12:42	69	Elite
12:23	48	Moderate

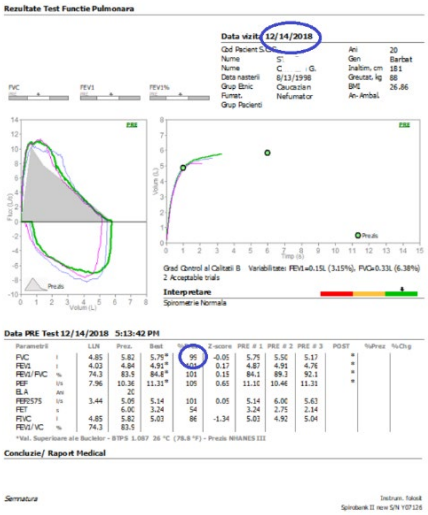
Source: https://flow.polar.com/progress/tests (2024)

Stage 4: In order to extrapolate the general information regarding health and fitness level, previously collected for each volunteer, the study continued with Forced Vital Capacity test (Medical International Research, 2023) aiming to emphasize any abnormalities or lung disfunctions. The spirometer device used factory settings (2018) and the procedure was supported by disposable turbines. The subjects took the spirometry test for maximum 3

BY-NC-SA 2024, Editorial Universitat Politècnica de València

consecutive tries: the best FVC value was encrypted into the journal (Figure 4). The test was conducted in the end of the class, *after* physical effort. A total of 28 subjects (Group A&B) passes throw such phase of the research. The Spirobank II software automatically predicted the graphics/performance based on The National Health and Nutrition Examination Survey (NHANES III) database.

Fig. 4 – Sample of Forced Vital Capacity test (2018)



Source: personal database

Stage 5: The final stage of the research revealed the general force items using deadlift technique (plyometric effort). The subjects performed gradually as many tries as needed in order to reach their best value. Weist-belt permitted; no hand wraps allowed. The Force-test was performed in the second part of the session, after specific warm-up (Cholewa, M.J. et al., 2019). In the end, the lifted weight was divided by body weight to extract the Relative Force Index (RFI). Fourteen subjects from Group A went through the test.

7. Data interpretation

As regards Gr. A: from a total of 222 available subjects, 24 agreed to volunteer for the research, 6 of them withdrew in various stages (no credits awarded), 8 skipped at least 1 stage of the research; in the end 10 subjects completed all 5 study stages. Students' perseverance, personal interest and attendance played an important role in data collection. The minimum attendance limit was the main reason for subjects' self-elimination from the study-group and not the amplitude/complexity of the effort during the classes (HRmax test/stage 3).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 1 – Centralized data (Group A) / selection

Initials gender	RHR b/min	HR max activity	VO2 max ml/kg/min	F.V.C. %	RFI
S.V.C.(m)	85	198 basket.	**61** Very good	96	**2.09**
S.G. (m)	**109**	186 running	45 moderate	**119**	1.15
M.A. (f)	83	202 basket.	34 fair	97	0.67
T.C. (m)	87	197 running	**73** elite	**122**	1.6
T.D.C. (f)	**100**	186 voleyball	41 moderate	94	1.3
T.A.G.(f)	**104**	call-off	27* low	**103**	no try
P.C.D. (m)	79	187 running	46 good	124	1.62

Source: Own elaboration

8. Conclusions

Subject S.V.C./basketball sport background (Table 1) was the only person who recorded RFI ≥ 2 (body weight 67 kg, deadlift 140 kg) but his very good 61 ml/kg/min maximal oxygen uptake was not supported by a higher than 100% FCV test (value 96). However, there was additionally 1 subject (T.C. / no previous sport history) with two excellent indexes (FVC = 122% & elite VO2 max = 73 ml/kg/min), but associated with a medium-value RFI = 1.6. No one from Gr. A was able to show all three superior items*. 5.1 hypothesis not confirmed.*

All 6 subjects (5 from Gr. A and 1 from Gr. B) identified in Stage 2 with RHR ≥ 100 b/min in sitting position were able to finish the surveillance programme and finally receive 2 credits from the examiner. Three out of five volunteers (e.g., T.A.G. & S.G. – Table 1) showed FVC values higher than 100%, meaning that their RHR particularity (sitting) was sustained by a well-developed respiratory system.

Seven subjects (including S.G. – Table 1) out of the 10 volunteers with all 5 stages completed were tested for the HRmax item on treadmill using a standardized protocol (last peak at V11 running speed - Figure 2). This type of controlled effort (running on treadmill) was sufficient to reach the 200 b/min HRmax value (±2), confirming that the formula *220 minus age* is a viable index – meaning that involvement was maximum during effort. No difference of HRmax between subjects with RHR ≥100 b/min in sitting position (peak 186 b/min during effort) and the others (181-200 b/min) was noted.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Superior HRmax values (≈ 200 b/min) were also recorded during bilateral game of basketball (sub S.V.C. & M.A. – Table 1). These values were totally dependent of subject's involvement in the game. *5.2 hypothesis was not confirmed*: however, it could be plausible in case of subject T.A.G. who called-off the HRmax surveillance programme during volleyball class.

This type of surveillance, based on medical & sports-licensed reliable equipment (Sakala,T. et al., 2022) could be implemented as a sustainable programme in many educational units for general benefits. We, as P.E. teachers, could be in the front-row of detection and prevention of any HR issues to our students - tachycardia included. (Gopinathannair, R. & Olshansky, B., 2015). The sooner the problem is identified, the better for everyone.

Acknowledgements

1. The technical support used during the research included the following licensed devices: Sanitas Pulseoxymeter – for SpO2 items; sports watches Polar V800 synchronized with H7 sensors (provided by Living Well s.r.l. – local Polar representative) – for Heart Rate diagrams and Orthostatic Test; digital Daewoo scale – for body weight control; Vision Fitness T 9800 treadmill – for maximum HR peak/fitness classes; Olympic barbells & weight disks complete set - for the deadlift test / maximal condition; metric scale – for height control; Spirobank II spirometer (Medical International Research) – for Forced Vital Capacity index; chronometer Geonaute – for time control;
2. Centralized sports background for Gr. A /10 subjects & Gr. B / 11 subjects: athletics, modern dancing, volleyball, karate-do, modern pentathlon, handball, aerobic gymnastics, swimming, field tennis; basketball, kick-boxing, football; Group C: 2 elite judokas;
3. Every volunteer (A&B) received during / in the end of the programme the HR, OT diagrams and FVC prints along with additionally collected VO2 max, SpO2, Force Indexes – brief interpretation provided.

Conflicts of interest

No known competing financial interests or personal relationships have influenced the work reported in this paper.

References

Cholewa, M.J. et al. (2019) - Anthropometrical Determinants of Deadlift Variant Performance, *Journal of Sports Science and Medicine* (2019) 18, 448-453, https://www.researchgate.net/publication/334160953_Determinants_of_Deadlift_Variant_Performance

Gopinathannair, R. & Olshansky, B. (2015) - Management of tachycardia, *National Library of Medicine*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4447058/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Medical International Research (2023) – Understanding normal values in spirometry: what to expect during a lung function test, https://spirometry.com/en/news/understanding-normal-values-in-spirometry-what-to-expect-during-a-lung-function-test

Moștoflei, F. (2017) - Project of Assisted Program Implementation at Physical Education Discipline to The Bucharest University of Economic Studies, *Marathon*, Physical Education and Sport Department, The Bucharest University of Economic Studies, Bucharest, Romania, vol. 9(2), 199-208, https://marathon.ase.ro/pdf/vol9/vol2/14-Mostoflei.pdf

Moștoflei, F. (2018) - Forced vital capacity & oxygen consumption screening at students, *4th International Conference on Higher Education Advances (HEAd'18)* Universitat Politecnica de Valencia, Valencia, 2018, DOI: http://dx.doi.org/10.4995/HEAd18.2018.8063

Navidi, W. (2015) – Controlled Experiments and Observational Studies, 2 Penn Plaza, *Statistics for Engineers and Scientists*, in McGraw-Hill Education, 11-12, New York, ISBN 978-0-07-340133-1

Sakala,T. et al. (2022) – Feasibility of evaluation of Polar H10 chest-belt ECG in patients with a board range of heart conditions, *Cor et Vassa* 2022, 64(4):411-422, DOI: 10.33678/cor.2022.083

Solan, M. (2021) – Your resting heart rate can reflect your current and future health, *Harvard Health Publishing*, https://www.health.harvard.edu/blog/your-resting-heart-rate-can-reflect-your-current-and-future-health-201606172482

Robergs, R. & Landwehr, R. (2022) - The surprising history of the "HRmax=220-age" equation, *International Journal of Online Engineering (iJOE)* 5(2), https://www.researchgate.net/publication/237258265_The_surprising_history_of_the_HRmax220-age_equation

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Gender equality in the clean energy transition: implementation of an academic toolkit in Bilbao School of Engineering (UPV/EHU)

Saroa Rozas[a], Natalia Alegría[a], Saioa Herrero [b] and Paula Serras [a]

[a]Bilbao School of Engineering, Energy Engineering Department, University of the Basque Country, Spain

[b] Bilbao School of Engineering, Department of Mechanical Engineering, University of the Basque Country, Spain

Abstract

In the framework of the European Union co-funded project *FemPower: gender equality in the clean energy transition*, an academic toolkit has been developed. The toolkit encompasses a comprehensive array of instructional resources and approaches that tacle gender-related prejudices and preconceptions within CET (Clean Energy Transition).

The toolkit is intended for master level students, preferably from energy engineering. For this reason, the aim of this work is to accomplish its pilot implementation in the Master's Degree in Industrial Engineering and the Master´s Degree in Sustainable Energy Engineering from Bilbao School of Engineering (University of the Basque Country, UPV/EHU).

The toolkit pilot implementation entails two activities that focus on understanding gender equality and challenging the stereotypes in CET. In the first activity, students should go through some selected material, share their opinions and answer different quizzes; whereas in the second activity, students should attend a presentation of gender issues related to CET challenges, think on their own experiences or observations and propose some solutions using the elevator speech methodology (University of Central Florida, 2024).

Some interesting findings from this experience are the grater awareness of gender equality in engineering and CET among students, the discussion about gender equality in the entire group and the proposal of solutions to promote gender inclusion in Bilbao School of Engineering, which would be suggested for its implementation in the near future.

Keywords: energy; engineering; equality; clean energy transition.

How to cite: Rozas,S.; Alegría, N.; Herrero, S. and Serras, P. (2024) Gender equality in the clean energy transition: implementation of an academic toolkit in Bilbao School of Engineering (UPV/EHU). In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 630-637.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

This work presents the implementation of an academic toolkit in the field of energy engineering. The aim of this toolkit is to work with Master level student the topic of gender equality in the Clean Energy Transition (CET). The toolkit has been developed in the framework of the European project *FemPower: gender equality in the clean energy transition* (FemPower: gender equality in the clean energy transition, 2024), and it is implemented in Bilbao School of Engineering (UPV/EHU), Spain. The aim of this toolkit is to make both, faculties and students, aware of the gender situation in CET and to bring out the topic of discussion. This will lead them finding possible actions to be done in academia and further in order to make stronger the presence of women in such an important and actual topic. The work is presented as follows: section 2 presents FemPower project and its objectives, section 3 describes Bilbao School of Engineering as a context of the implementation of the tookit, section 4 introduces the methods and materials used in the toolkit, section 5 sets the results to be obtained after implementing the toolkit and, finally, section 6 presents the conclusions of the work.

2. FemPower: gender equality in the clean energy transition

FemPower is a Cooperation Partnership in Higher Education that aims to increase female representation in the energy sector, empower and prepare those who are already active in academia or the market, and integrate the gender dimension in CET research and development. This project involves five Higher Education Institutions (Aristotle University of Thessaloniki in Greece, Politecnico di Milano in Italy, Cyprus University of Technology in Cyprus, Technical University of Delft in Netherlands and University of the Basque Country in Spain), one Small and Medium Enterprise (DuneWorks in Netherlands), two Non-Govermental Organization (Digijeunes in France and Diotima in Greece) and one Public Body (Center for the Promotion of Science in Serbia).

2.1 Objectives

The objectives of this project are as follows:

- Develop methodologies and tools to establish gender mainstreaming in the CET.
- Develop, test and evaluate transversal Open Educational Resources (a Massive Open Online Course and an interactive map) and a gender mainstreaming checklist especially for Higher Education Institutions (HEIs) in the field of CET to raise gender awareness in CET education and increase female participation in the research activities of the involved organizations.
- Develop gender inclusive co-creation methodologies for cross-sectoral and international cooperation in the field of CET, as well as test and evaluate them.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Develop gender inclusive STEAM educational methodologies in the field of CET to support, empower and improve the gender awareness of the students and staff in the participating HEIs as well as increase their multidisciplinary and creative skills for the CET.
- Develop gender inclusive CET STEAM activities for Secondary Education to increase the number of students and especially girls interested in CET careers that will be tested during a pilot implementation.
- Ensure and promote future long-term sustainability of the implemented solutions by creating and maintaining the Fem to FemPower Peer Learning Network.

2.2 Expected project results

The aim of the project is to achieve the following results:

1. Mapping and comparison of current situation of the Clean Energy Transition and Gender Equality.
2. A gender analysis of the Clean Energy Transition.
3. MOOC – Gender Equality and the Clean Energy Transition.
4. Gender mainstreaming Higher Education: checklist for CET education in Higher Education Institutions.
5. Gender inclusive co-creation strategies for the cooperation of diverse stakeholders in the field of energy.
6. Gender inclusive Clean Energy Transition STEAM activities in Higher Education – toolkit.
7. Gender inclusive Clean Energy Transition STEAM activities for Secondary Education – Handbook.
8. Fem to FemPower Peer Learning Network.

In this sense, the present work aims to study in depth the work carried out in the project result number 6 by the implementation of the toolkit created by Cyprus University of Technology in two master's degree subjects at Bilbao School of Engineering, at the University of the Basque Country (UPV/EHU).

3. Implementation context: Bilbao School of Engineering

3.1 Origins

In this work, we present the implementation of the tools developed in FemPower project in Bilbao School of Engineering. The current Bilbao School of Engineering was founded in 2016 when 4 different schools merged giving rise to the largest faculty in the University of the Basque Country. The former schools were the Higher Technical School of Engineering in Bilbao (founded in 1897), the School of Technical Engineering in Bilbao (founded in 1942), the

 BY-NC-SA

School of Technical Engineering of Mines and Public Works in Bilbao (founded in 1913), and the Higher Technical School of Nautical and Naval Machinery (founded in 1739). Thus, although the official date of foundation of the School is recent, the real origin of the School dates back to the XVIII century. This fact makes the School very present in the society that surrounds it, being the reference in the industrial network of the North of Spain. In such predominantly male fields as industry and engineering have traditionally been, the Bilbao School of Engineering is involved in different actions to make visible the work done by different female engineers (trained at the School or teachers and researchers of it) and to promote the vocation for engineering among the new generations. However, this is not an easy task and the number of women in Bilbao School of Engineering is still much lower than the number of men.

The main objectives of the academic and research programmes of Bilbao School of Engineering align with the 17 Sustainable Development Goals (SDG) set by the United Nations. In order to accomplish our goals, the Management Team of the School has appointed a Quality Commision and an Equality Commission. The Quality Commission promotes excellence in teaching and research by offering training activities for teachers, promoting innovative teaching techniques and guiding our School to obtain the new European EMAS environmental certification. The Equality Commission is composed of professors, students and administrative staff of the School and its aim is to monitor gender equality in the different sectors of the School and organize activities to promote and ensure gender equality.

3.2 Current numbers

Bilbao School of Engineering currently offers 12 Bachelor Degrees and 17 Master Degrees taught by 13 different departments. The school has currently 4,755 students, of which 3,510 (74 %) are men and 1,245 (26 %) are women. The difference reduces when we compare the number of female and male professors and researchers: 448 (66 %)male vs 231 (34 %) female. And the difference reduces even more when it comes to the number of women and men in management positions: the management team is made up of 6 women and 7 men. This data is summarized in Table 1, specifying the number of students enrolled in Bachelor´s and Master´s Degrees.

Table 1 – Distribution by gender of students and professors/researchers in Bilbao School of Engineering

Type	Level	Male	Female	Total
Students	Bachelor	2,779	993	3,772
Students	Master	731	252	983
Professors	--	448	231	679

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.3 Degrees related to clean energy transition

Among the Master´s Degrees offered by Bilbao School of Engineering, students can choose several energy specialities offered in the Master's Degree in Industrial Engineering (hydraulic engineering, and nuclear and radiological engineering) and in the Master´s Degree in Sustainable Energy Engineering, which includes the energy generation and its management.

Table 2 shows the number of male and female students enrolled in the specialities of the Master´s Degree in Industrial Engineering related to energy and in the Master´s Degree of Sustainable Energy Engineering.

Table 2 – Master students enrolled in energy related specialities in Bilbao School of Engineering

Master´s Degree	Speciality	Gender	Total number
Industrial Engineering	Hydraulic Engineering	Male	9
		Female	4
		Total	13
Industrial Engineering	Nuclear and Radiological Engineering	Male	7
		Female	2
		Total	9
Sustainable Energy Engineering	-----	Male	17
		Female	7
		Total	24

Source: Own elaboration

In relationship with the hydraulic engineering speciality, in Bilbao School of Engineering there are several Company Rooms, one of them being the Consortium of Water Bilbao Bizkaia (CABB) Water Hall. In this hall, the students prepare the Bachelor´s Thesis and the Master´s Thesis working for the CABB. This academic year, there are 9 students participating in the CABB Water Hall, 3 of them being women.

With the students of hydraulic engineering and nuclear and radiological engineering, and the students of the master's degree in Sustainable Energy Engineering, the FemPower group of Bilbao has planned two activities for the pilot implementation of the toolkit.

4. Methods & Materials

The developed toolkit for higher education in the Clean Energy Transition fosters equitable and inclusive learning environments following a STEAM approach. It encompasses a comprehensive array of instructional resources and approaches that tacle gender-related prejudices and preconceptions within CET. The toolkit strives to empower students, regardless of gender, to actively engage in clean energy studies and professions, while aligning with Bloom´s Taxonomy (The Glossary of Education Reform, 2024) to promote deeper cognitive learning outcomes.

 BY-NC-SA

Bloom's Taxonomy is a widely recognized pedagogical framework that categorizes different levels of cognitive processes involved in learning. According to the educational goals and objectives of the toolkit, it encomprises six levels of cognitive complexity in the revised Bloom's Taxonomy (Anderson and Krathwohl, 2001), from lower-order to higher-order thinking skills: remembering, understanding, applying, analyzing, synthesizing and evaluating (Laddha et al., 2021).

Thus, the toolkit activities for introducing gender in the curricula are: *Understanding Gender Equality in Clean Energy Transition* and *Challenging the stereotypes in Clean Energy Transition*.

4.1 Understanding Gender Equality in Clean Energy Transition

The aim of the first activity to be implemented is to understand gender equality in the field of CET, following these steps:

1. Material selection: among the options from the database of the toolkit, which introduce gender-related challenges in CET, our group choose two videos (NAP Global Network, 2024), (NC Sustainable Energy Association, 2024), two articles (Sertyesilisik, 2022), (Baruah and Gaudet, 2022), and one website (EU Science Hub, 2024) and share them with their student groups before the next step.
2. Individual navigation: both, at home (before the activity in classroom) and at classroom (during 25 minutes), our group allow their students to go through the selected material.
3. Sharing and presentation: each student group share with the entire class their observations, comments and opinions about the studied material and discuss together, for about 25 minutes.
4. Quiz: finally, in 10 minutes, students answer the quizzes about challenges of women in CET, by Kahoot, and about gender equality in CET, by Google Forms; and share their scores.

4.2 Challenging the stereotypes in Clean Energy Transition

The second activity aims to challenge the stereotypes in CET, which consists of the following steps:

1. Presentation of gender related challenges in CET by our group members, including videos with experiences in the field (10 minutes).

2. Reflection on students' own experiences or observations in the field of CET (10 minutes).

3. Proposing a solution by *elevator speech* (University of Central Florida, 2024) activity, which engage participants in critical thinking, while honing their communication skills (60 minutes).

The *elevator speech* shoul have to include next steps:

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Provide participants with an *elevator speech* template.
- Encourage them to consider specific data, examples, or case studies related to gender equality challenges in Clean Energy.
- Divide participants into small groups.
- Ask each group to work on crafting an *elevator speech* using the template.
- Encourage them to exchange ideas and perspectives within their groups.
- Invite each group to share their *elevator speech* with the larger group.
- Facilitate a discussion on the strengths and unique aspects of each speech.
- Encourage critical feedback and insights.
- Conclude the activity with a brief reflection on the importance of gender equality in the Clean Energy transition and the role of higher education in driving positive change.

5. Results

The results of the implementation of toolkit shown an increase of the interest in gender equality in the field of engineering in general and, specifically, in the field of clean energy. This can be observed after completing the activity 4.1. From the data collected by the quizzes, in Kahoot and Google Forms, and the views of the material provided to students, it is proven that student concern has grown.

During the discussion with the professors is has been observed a building of the critical thinking about gender equality in engineering among students. These results are obtained from the elevator speech template and completing the activity 4.2. In the template, students have identified and analysed a specific challenge or gap related to gender equality in engineering and proposed some strategies for a better promotion of gender equality.

Finally, specific actions to be carried out in Bilbao School of Engineering to promote gender inclusion have been proposed from students and professors. This result is obtained after completing the activity 4.2 and proposed specific action for a better promotion of gender equality in the School by a template.

6. Conclusions

This work has introduced a toolkit to be used in classes with students of Master´s Degree in Bilbao School of Engineering (UPV/EHU), Spain. The toolkit will allow students and faculty to discuss the importance of the presence of women in the clean energy transition, and also to propose actions to increase awareness among the School community.

 BY-NC-SA

Acknowledgements

FemPower is a project co-funded by the European Union under the Erasmus+ KA220 – Cooperation Partnerships in Higher Education call by the Hellenic National Agency, Grant Agreement No: 2021-1-EL01-KA220-HED-000030178.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Anderson, L. W., & Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing*. Pearson.

Baruah, B., & Gaudet, C. (2022). Creating and Optimizing Employment Opportunities for Women in the Clean Energy Sector in Canada. *Journal of Canadian Studies*, *56*(2), 240–270. https://doi.org/10.3138/jcs.2019-0010

Build Your Educational Elevator Speech. (n.d.). Academic Advancement Programs. Retrieved April 26, 2024, from https://academicsuccess.ucf.edu/aap-guidetogradschool/topic/2h-build-your-educational-elevator-speech/

D. Laddha, M., T. Lokare, V., W. Kiwelekar, A., & D. Netak, L. (2021). Classifications of the Summative Assessment for Revised Bloom's Taxonomy by using Deep Learning. *International Journal of Engineering Trends and Technology*, *69*(3), 211–218. https://doi.org/10.14445/22315381/ijett-v69i3p232

Employment in the energy sector – European Commission. (n.d.). Joint-Research-Centre.ec.europa.eu. Retrieved January 6, 2024, from https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/employment-energy-sector-2020-07-09_en

FemPower – gender equality in the clean energy transition. (n.d.). Retrieved April 26, 2024, from https://fempower.ee.auth.gr/

Great Schools Partnership. (2014, March 5). *Bloom's Taxonomy Definition*. The Glossary of Education Reform. https://www.edglossary.org/blooms-taxonomy/

Sertyesilisik, B. (2022). Empowerment of Women and Increasing Women Employment in the Construction Industry to Support Environmental Sustainability and Sustainable Development. *Environmental Sustainability, Growth Trajectory and Gender: Contemporary Issues of Developing Economies*, 255–265. https://doi.org/10.1108/978-1-80262-153-220221020

Why Gender Matters for Effective Adaptation to Climate Change. (2021, August 27). NAP Global Network. https://napglobalnetwork.org/2021/08/gender-effective-adaptation-climate-change/

WICE | North Carolina Sustainable Energy Association (NCSEA). (n.d.). NC Sustainable Energy Association. Retrieved April 26, 2024, from https://energync.org/wice/

WICE | North Carolina Sustainable Energy Association (NCSEA). (n.d.). NC Sustainable Energy Association. Retrieved April 26, 2024, from https://energync.org/wice/

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Education for sustainability in a secondary and vocational training center

Elisa Adell[a]

[a]Department of Vocational Training Education, IES Federica Montseny, Burjassot, Valencia, Spain

Abstract

Educational institutions have a key role in sustainability. They are the key agents in the education of future citizens who will contribute to the implementation of the SDGs. To achieve this, it is necessary to adapt the organization and operation, as well as the environmental management of the educational center with a clear and defined strategy. The IES Federica Montseny, secondary and vocational training school, has designed an Educational Social Responsibility Plan in which sustainability is one of the fundamental pillars. The lines of work of this plan are described, emphasizing the actions that are carrying out to improve the sustainability of the center. The actions carried out focus on 5 large areas, which are: improving the center's energy efficiency, control and reduction of water consumption, waste management, promotion of biodiversity and raising awareness. Moreover, the educational center proposes several specific actions to carry out in upcoming courses. This educational center demonstrates its commitment to sustainability by implementing practices and policies that contribute to the protection of the environment and sustainable development and ensure quality education. In addition, the actions that are carrying out could be an example for other educational centers that want to advocate for guaranteeing a sustainable future.

Keywords: sustainability; SDGs; quality education; awareness.

How to cite: Adell, E. (2024) Education for sustainability in a secondary and vocational training center. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 638-645.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The Agenda 2030, approved by the United Nations in 2015, established the Sustainable Development Goals (SDGs). These 17 goals constitute a universal call to action to end poverty, protect the planet and improve the lives and prospects of people around the world (UNESCO, 2017). Specifically, SDG No. 4 seeks to guarantee inclusive, equitable and quality education, and promote lifelong learning opportunities for all. In addition to being an end in itself, education is considered a key instrument for achieving all the SDGs (Romero and Careaga, 2017) and in particular education for sustainable development (UNESCO, 2017).

Educational institutions have a fundamental role in sustainability. They are the key agents in the education of future citizens who will contribute to the implementation of the SDGs. As a transformative agent, the education sector has a tremendous impact on the habits of students and their contribution to a prosperous society. However, to establish the required change in education, sustainability principles must be at the center of the strategy of educational institutions (Žalėnienė and Pereira, 2021). Thus, any educational center that moves towards sustainability needs to set quality, educational and social objectives, in line with the SDGs. Therefore, it is necessary to adapt the organization and operation, as well as environmental management, and to encourage the participation of the center's staff (Mogensen et al., 2005). It is not just about changing environmental management, but rather coherence is needed between methodology, content and school environment (Salomone, 2007).

In recent years, numerous works and reviews have been published that evaluate the impacts and presence of sustainability principles in university courses, course content and learning (Littledyke et al., 2013; Findler et al., 2018 , Fuertes-Camacho et al., 2019; Carracedo et al., 2019). Methodologies used in higher education have also been published (Gatti et al., 2019), however, there is little information regarding secondary education or vocational training. Some specific practical experiences have been published (Gozalbo and Ruiz-González, 2018), however, it is important to have a center sustainability plan as a fundamental pillar that structures all the actions carried out by an educational center with a clear and defined strategy.

With this communication we intend to make known how an institute of secondary education and vocational training is committed to sustainability as a tool to improve educational quality and promote the care and maintenance of the environment, thus guaranteeing a sustainable future and serve as a reference for other secondary education and vocational training centers. This educational center has designed an Educational Social Responsibility Plan in which sustainability is one of the fundamental pillars. The lines of work of this plan are described below, emphasizing the actions that are carrying out to improve the sustainability of the center.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Context and students

This educational center is a public secondary school, located in the town of Burjassot, in the metropolitan area of the city of Valencia. It integrates students from Compulsory Secondary Education (ESO), Baccalaureate, Basic Vocational Training and intermediate and higher-level vocational training from 6 Professional Families: Safety and Environment, Electronic Electricity, Installation and Maintenance, Mechanical Manufacturing, Health and Commerce. A total of around 1,300 students attends this center, approximately 80% are vocational training students.

3. Scope of application and strategic lines of the Educational Social Responsibility plan

The IES Federica Montseny Educational Social Responsibility Plan affects all activities, areas and services offered at the educational center.

The Strategic Lines currently being worked on are:

STRATEGY LINE 1: COMMITMENT TO RESPONSIBLE GOVERNMENT

STRATEGY LINE 2: EMPLOYABILITY

STRATEGY LINE 3: PEOPLE/HEALTH AND WELL-BEING

STRATEGY LINE 4: COMMUNITY/SOCIAL ACTION

STRATEGY LINE 5: SUSTAINABILITY

Regarding strategy line 5: Sustainability, it is specified in:

- Reduction of the impacts of our activity
- Environmental awareness to contribute to critical and responsible citizenship
- Incorporate sustainability criteria in the selection of suppliers, companies...

4. Implemented actions

The actions carried out focus on 5 large areas, which are: improving the center's energy efficiency, control and reduction of water consumption, waste management, promotion of biodiversity and awareness.

Furthermore, a strong point of this educational center is that a group of teachers has been created in charge of ensuring an improvement in sustainability at the center whose main functions are to propose the actions that will be carried out annually, as well as review and ensure that the implemented measures are effective. Another of its important tasks is to promote and encourage sustainability in the center.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4.1 Energy efficiency

The main objective of this work area is to reduce energy and gas consumption, to this end several actions have been carried out:

- **Installations of photovoltaic solar panels.** There is a 60 kw installation and it is planned to expand it with another 60 kw in the coming months, which supplies energy to the center. The institute belongs to the "zero program, proximity energy", so that the surplus energy is intended to supply the adjacent neighborhood, which is a neighborhood with a low socioeconomic level.
- **Change of lighting.** A large part of the lighting has been changed to low-consumption lighting (LED) both in classrooms and hallways, in the gym, patio or parking area. The change of lighting in classrooms and hallways is being carried out by the teachers of the energy efficiency group and students of the electronics cycles, as part of a project that they work on in the classroom using active methodologies.
- **Lighting sectorization.** Presence detectors have been installed in the hallways to provide lighting only when necessary. As for the classrooms, the lighting is being divided into zones to only turn on the necessary lights.
- **Installation of timers.** Timers have been installed on classroom computers so that they do not stay on overnight.
- **Heating control.** Installation of solenoid valves with Wi-Fi that record the classroom temperature in real time to turn the heating on or off as needed. In addition, an action protocol has been established with recommendations for teachers to make appropriate use of heating in classrooms.
- **Monitoring of electricity and gas consumption.** A periodic (weekly) review of the meters is carried out and consumption is recorded. This is intended to detect possible leaks.

4.2 Water consumption

The main objective is to control and reduce water consumption; to this end, several actions have been carried out:

- **Consumption contro**l. A weekly review of the water meter is carried out to detect possible leaks or excessive expenses.
- **Installation of taps with sensors.** Most taps have been replaced by taps with sensors.
- **Control of garden irrigation.** Drip irrigation of the garden has been programmed to control the irrigation time and the amount of water according to the water needs of the plants.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4.3 Waste management

To improve waste management and reduce its environmental impact, separate collection of paper/cardboard, packaging, toners, batteries, metals, wood, appliances and toxic waste is carried out.

It must be taken into account that given the characteristics of the teachings taught at the center, various waste that is potentially polluting for the environment is generated, such as waste from laboratories and mechanical workshops.

Non-urban and hazardous waste are collected by specialized companies for proper recycling.

4.4 Promotion of biodiversity

Promoting biodiversity in the center is essential to maintain urban ecosystems in a way that ensures a healthy environment for the center's students and staff. Furthermore, these actions aim to raise awareness among students about the importance of conserving natural resources and their sustainable use. The specific actions that have been carried out are:

- **Garden with native plants**. Native plants from the Valencian Community such as rosemary or lavender, among others, have been planted in the school garden area.
- **Insect huts**. Insect huts have been installed to promote biodiversity as well as houses for birds and bats. The installation is as part of a project that students work on in the classroom using active methodologies.

4.5 Raising awareness

An important part of the actions carried out are all those that focus on raising awareness among students and teachers and thus making them participate in improving sustainability both at the center and in its immediate surroundings. In addition, it is intended that students understand how their daily actions affect the environment and society.

Some specific activities that have been carried out to raise awareness and make people reflect are:

- **Teacher awareness**: elimination of paper to carry out procedures, promotion of the VET Sustainability Guide.
- **Involvement of the students in the sustainability projects of the educational center**: change of lighting by the students of the electronics training cycles; maintenance of the garden and native plants by ESO students in the biology subject; making houses for bats and birds in the technology subject also by ESO students.
- **Participation in competitions related to sustainability**: participation in mov.ia by Ineco Hackathon whose challenge was to achieve more sustainable mobility and Efiaqua Hackathon focused on the decarbonization of water. In these two contests

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

our students were winners. Participation in FP Skills whose objective was to promote more sustainable tourism in the Valencian Community. Carrying out a Hackathon at the institute "Innovating for a sustainable future" with the objectives of promoting the development of skills that contribute to the employability of students and raising awareness among students about the importance of being active agents in the sustainability of the planet.

- **Celebration of health day**: promotion of healthy living habits, recycling, mental health, hygiene through games and participatory dynamics.
- **Reflection on the SDGs**: implication of the SDGs in the projects that students do in the subject of Business and Entrepreneurship.

Thus, the students are aware of each of the actions described above and the teachers are responsible for transmitting the importance of these small actions to improve sustainability and reduce the environmental impact.

5. Active teaching methodologies and sustainability

Sustainability is worked on by involving students in the different projects and activities carried out at the institute using active methodologies.

Several initiatives have been carried out through project-based learning (PBL) so that students learn by doing. For example, the installation of solar panels: the students have designed the installation, carried out the calculations, chosen the materials and assembled the installation. The result of this work is the installation in operation, which represents energy savings for the institute and the planet. Another example of PBL is the assembly of insect huts. In the same way, the students have designed, chosen the materials and built the insect huts, which are placed in the garden area to promote biodiversity.

The Design Thinking methodology has been used in the Hackathon organized by the institute for higher-level vocational training students. The results of this experience show that it has contributed to developing skills of empathy, research and entrepreneurship, in addition to raising awareness among students of the importance of being active agents in the sustainability of the planet.

6. Actions to implement in upcoming courses

With the purpose of continuous improvement in sustainability, several specific actions are proposed to be carried out in upcoming courses such as:

- Plant native trees
- Expand the installation of photovoltaic panels for more efficient air conditioning in classrooms.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- Change of toilet cisterns for double-load cisterns.
- Study the possibility of implementing chargers for scooters, electric bicycles and cars in the future.
- Take advantage of the opportunities we have to participate in projects related to microplastics, food justice or the environmental impact of the industry.

7. Conclusion

Educational institutions have a great responsibility in training citizens who will contribute to the implementation of the SDGs. The IES Federica Montseny demonstrates its commitment to sustainability by implementing practices and policies that contribute to the protection of the environment and sustainable development and thus ensure high educational quality. Active methodologies are an important bet to work on sustainability in the center. Several initiatives have been carried out through project-based learning so that students learn by doing, such us the installation of solar panels or insect huts. The Design Thinking methodology has been used in the Hackathon "Innovating for a sustainable future" organized by the institute. Through its focus on environmental education and the promotion of social responsibility, the educational center has managed to motivate the educational community to take positive measures to care for and maintain the environment and thus guarantee a sustainable future. In addition, we intend that our actions serve as an example for other centers in education for sustainability.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Carracedo, F. S., Ruíz-Morales, J., Hernández, R., Muñoz-Rodríguez, J., & Gomera, A. (2019). Analysis of the presence of sustainability in higher education degrees of the Spanish university system. Studies in Higher Education, 46(2), 300-317. https://doi.org/10.1080/03075079.2019.1630811

Education for Sustainable Development Goals: Learning Objectives. (2017). En UNESCO eBooks. https://doi.org/10.54675/cgba9153

Fernández, I. A., & Quintero, J. A. J. (2013). Experiencias internacionales en materia de responsabilidad social universitaria. Visión de Futuro, 17(1), 1-16. https://dialnet.unirioja.es/descarga/articulo/5234046.pdf

2024, Editorial Universitat Politècnica de València BY-NC-SA

Findler, F., Schönherr, N., Lozano, R., & Stacherl, B. (2018). Assessing the Impacts of Higher Education Institutions on Sustainable Development—An Analysis of Tools and Indicators. Sustainability, 11(1), 59. https://doi.org/10.3390/su11010059

Fuertes-Camacho, M. T., Graell-Martín, M., Fuentes-Loss, M., & Balaguer-Fàbregas, M. C. (2019). Integrating sustainability into higher education curricula through the Project Method, a global learning Strategy. Sustainability, 11(3), 767. https://doi.org/10.3390/su11030767

Gatti, L., Ulrich, M., & Seele, P. (2019). Education for Sustainable Development through Business Simulation Games: An Exploratory study of sustainability gamification and its Effects on students' learning Outcomes. Journal of Cleaner Production, 207, 667-678. https://doi.org/10.1016/j.jclepro.2018.09.130

Gozalbo, M. E., Baltar, D. Z., & Ruiz-González, A. (2018). Huertos EcoDidácticos y Educación para la Sostenibilidad. Experiencias educativas para el desarrollo de competencias del profesorado en formación inicial. DOAJ (DOAJ: Directory of Open Access Journals). https://doi.org/10.25267/reveurekaensendivulgcienc.2018.v15.i1.1501

Littledyke, M., Manolas, E., & Littledyke, R. (2013). A Systems Approach to Education for Sustainability in Higher education. International Journal of Sustainability in Higher Education, 14(4), 367-383. https://doi.org/10.1108/ijshe-01-2012-0011

Mogensen, F., Breiting, S., & Mayer, M. (2005). Quality criteria for ESD-Schools: guidelines to enhance the quality of education for sustainable development. Austrian Federal Ministry of Education, Science and Culture. https://doi.org/10.1007/978-3-319-09549-3_3

Romero, A. G., & Careaga, S. A. (2017). El papel de la universidad y la Cooperación Universitaria al Desarrollo en el nuevo escenario de la Agenda 2030. Revista Española de Desarrollo y Cooperación, 41, 13-24. https://dialnet.unirioja.es/servlet/articulo?codigo=6187114

Salomone, M. (2007). Écologie de l'institution scolaire – la cohérence entre contenus, méthodes et milieu scolaire. Education relative à l'environnement: regards-recherches-réflexions, Volume 6. https://doi.org/10.4000/ere.3899

Žalėnienė, I., & Pereira, P. (2021). Higher Education for Sustainability: A Global perspective. Geography and Sustainability, 2(2), 99-106. https://doi.org/10.1016/j.geosus.2021.05.001

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Development of a 3D virtual world tool for sustainable energy education

Marta Guerra-Mota[a], Minas Dimosthenis[b], Michalis Xenos[b] and Maria Manuel Sá[c]

[a]Department of Business Sciences and UNICES, University of Maia, Portugal
[b]Department of Computer Engineering and Informatics, University of Patras, Greece
[c]Department of Business Sciences, University of Maia, Portugal and NECE-UBI, Research Centre for Business Sciences, 6200-209 Covilhã, Portugal

Abstract

The UNESCO (2022) points out that the gap between the existing awareness of a person or a community, and the actual habits of everyday life, is attributed to: low levels of understanding the environmental issues at stake; low levels of knowledge regarding energy and climate issues; and lack of attention to social, emotional or behavioral learning. In this context, as environmental and energetic concerns grow rapidly in our daily lives, RAISE - Raising environmental knowledge & awareness, an ERAMUS+ project with partners from three countries (Greece, Portugal, and Italy), was born. The project's first and main objective is to increase the environmental knowledge and awareness (EK&A) of schoolchildren. To achieve this goal, a survey was first carried out to ascertain the students' knowledge and, based on these results, scenarios and educational material were drawn up to build a pedagogical tool - a 3D Virtual World Learning Environment (3D VWLE). This paper presents the desktop research results and the main features of the game that are intended to match the identified educational needs. The 3D VWLE puts students in situations where they can acquire transferable skills. The project demonstrated that the simulation effect of 3D VWLE on skills provides an excellent online learning environment for students to work on and improve their abilities. In other words, virtual worlds open the door to a new way of learning and teaching.

Keywords: energy education; gamification; student centred techniques; 3D virtual world; educational tool.

How to cite: Guerra-Mota, M.; Dimosthenis, M.; Xenos, M. and Sá, M.M. (2024) Development of a 3D virtual world tool for sustainable energy education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 646-654. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

It is widely acknowledged that energy consumption has become a critical facet of modern living; a significant proportion of individuals and organizations now dedicate considerable resources to managing energy use, exploring renewable sources, and leveraging technology for more efficient energy consumption. Despite the benefits that come with advancements in energy technologies, such as reduced greenhouse gas emissions, increased energy security, and economic savings, there are also notable challenges and negative impacts associated with our current energy practices, including environmental degradation, resource depletion, and the exacerbation of climate change. The complexity of the energy landscape necessitates informed decision-making; education emerges as a pivotal tool for enhancing understanding and awareness around critical energy issues. In response to this need, this paper introduces an innovative educational approach designed to enrich knowledge and implementation of this educational initiative, the paper aims to contribute significantly to improving awareness and actions regarding sustainable energy practices, highlighting the essential role of education in navigating the energy challenges of the 21st century.

This educational tool represents an advanced online, three-dimensional virtual world designed to encompass a broad spectrum of energy education concepts, including but not limited to wind farm management. It serves as an immersive platform where users can engage with various energy-related scenarios, ranging from renewable energy sources like wind and solar, to the intricacies of energy efficiency, grid management, and the environmental and societal impacts of energy choices. Through interactive simulations, users encounter real-life challenges such as optimizing renewable energy production, balancing energy demands with supply, and mitigating the negative effects of energy consumption on the environment.

The primary goals of this paper are to introduce this comprehensive educational tool, detail the diverse scenarios that have been developed to cover a wide range of energy topics, discuss the methodologies employed for evaluating its effectiveness, and share the outcomes achieved from its implementation. Additionally, the paper explores how this three-dimensional virtual world contributes to the learning process, enhancing the educational journey for students enrolled in pre-university studies.

Research in learning indicates that hands-on learning is an active and constructive process and becomes more impactful when rooted in real-world learning styles (Bransford,2000); methodologies such as problem-based learning, cooperative learning, and activity-led learning can significantly enhance students' critical thinking skills. Moreover, effective learning arises from the interaction between an actively engaged learner and a supportive, stimulating learning environment (Lombardo, 2009). In this context, the 3DVW (Three-Dimensional Virtual World) introduced in this paper provides the ideal infrastructure to offer

(cc) BY-NC-SA 2024, Editorial Universitat Politècnica de València

learners a comprehensive understanding of various situations through immersive experiences, facilitating a hands-on approach to learning that leverages the engaging and interactive potential of virtual environments.

The development and use of 3D Virtual World Learning Environment (3D VWLE) for educational purposes represents a dynamic area that expands and enriches the concept of educational spaces. In such environments, learners have the freedom to navigate, explore, engage in activities, make errors, and collaborate or communicate with peers. The primary goal within a 3D VWLE is to foster a sense of immersion, allowing learners to feel as though they are truly part of the environment. This immersion, combined with interaction with virtual elements, can significantly boost learners' interest and engagement in educational tasks, potentially leading to a deeper understanding of concepts contingent on the subject manner.

Within this immersive 3DVWLE, users are transported into an engaging virtual setting where they encounter real-life energy threat scenarios. These scenarios are ingeniously presented as interactive games, allowing users to navigate through, engage with, and learn about various aspects, risks and threats associated with energy use. The design of this educational tool leverages the immersive and interactive capabilities of 3DVWLEs to simulate experiences that mirror real-world challenges. However, it ensures that learners can explore these serious issues in a manner that is both safe and enjoyable.

The educational tool's focus on energy saving and addressing energy threats through a 3D VWLE represents a significant step forward in environmental education. It showcases how advanced digital technologies can be harnessed to tackle critical issues, making complex concepts more accessible and engaging for a broader audience (Grivokostopoulou et al. 2020). This approach not only educates but also empowers individuals with the knowledge and experience needed to make informed decisions and act towards a more sustainable future (An, 2019; Lo, 2022).

2. Methodology

The methodology was divided into three main phases. Firstly, desktop research was performed, to identify critical issues in the energy and environment fields, based on a literature review and analysis of reports from reference organizations. The creation of a questionnaire to assess the knowledge, behavior, and awareness of school pupils relating energy and environmental issues. This activity was sourced on the results of the previous phase and on a review of the literature on education for sustainability. The data obtained of the respondents was subjected to statistical analysis and discussion to support the scenarios proposals. Finally, the scenarios were developed, which, through a narrative in which the player is involved, enable the proposed learning objectives to be met.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The questions from the survey were elaborated after consulting international scientific articles on the topic (Michalos et al., 2012; Gericke et al., 2018; Lestari et al., 2022). Although these authors only used questions with a Likert scale response, the project team chose to also pose multiple choice questions and questions with optional answers. Thus, the block consists of 21 questions with optional answers and one multiple choice question; the Attitudes block consists of 4 questions with optional answers and 6 questions on a Likert scale (from 1 Strongly disagree to 5 Strongly agree); the Behavior block consists of 24 questions with Likert scale answers (from 1 Never to 5 Often). The survey consisted of a sociodemographic set of questions (with the variables age, gender, country, and school year) and the three blocks with questions about knowledge, attitudes and behaviors regarding energy and climate issues. The questionnaire was carried out using the software LimeSurvey in English, Greek, Portuguese, and Italian versions. The data has been collected through an online survey in three basic and secondary schools of the partners involved in the research. Students from Arseiko Lyceum of Patra from Greece, Agrupamento de Escolas D. Afonso Sanches from Portugal, and Liceo Manin from Italy. The criteria defined for the inclusion of participants in the sample were: (a) students from basic and secondary school; (b) female and male gender; (c) acceptance to participate voluntarily in the study with the informed consent of the parents. The data collection instruments were administered to the students online via the schools' computers. The questionnaires were previously validated by a group of 10 students in each school to identify opportunities for improvement or difficulties in interpreting the questions. As no issues to be changed were identified, the questionnaires were then disseminated to a larger group of students. The sampling and data collection process took place between the 1st and 31st of March of 2023. Data was processed using version 28.0 of the Statistical Program for Social Sciences (IBM SPSS). The results obtained were subjected to a statistical analysis which identified the critical areas in terms of knowledge and attitudes towards environmental and energy issues, which supported the scenario development of the virtual world.

For the development of the 3D Virtual World (3DVW), a comprehensive survey of available open-source virtual world platforms was undertaken (Maratou et al., 2015). OpenSimulator was selected for its robust features, including a built-in 3D Editor, scripting capabilities, and server infrastructure. This choice enabled the crafting of dynamic, fully interactive multi-user 3D environments from the ground up. OpenSimulator's architecture facilitates the creation of immersive virtual spaces where users can engage in a variety of educational activities, enhancing the learning experience with its interactive and engaging virtual environments.

3. Results and discussion

Energy issues cut across a wide range of topics, from technology, greenhouse gas emissions, consumption and production, transport, among others, which were addressed in the survey.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

It was intended to be comprehensive to cover different energy-related topics that could support interesting and challenging scenarios.

Regarding the questions in the Knowledge Section (Save energy): the renewable energy most known to students is solar energy (95.1%) followed by wind energy (92.2%). The least known renewable energy is biomass (52%) followed by ocean energy (54.6%). This shows that there are renewable energy alternatives that are little known to young people and/or that some forms arouse greater interest, such as wind or solar energy. Regarding the Behavior section, in general, students recycle and engage in energy-saving behavior. However, 15 to 20% do not encourage their family and/or friends to do the same. Also, more than 50% of the students never or rarely get involved in activities related to gardening and growing fruits and vegetables. Although students consider it a positive attitude to join an environmental group, 58.5% of students never collaborate with an environmental group that works to protect the environment and promote sustainability. Only 37,7% of participants always or often share the car with friends or neighbors. 61,1% of the participants have never taken part in a protest action in defense of the environment. Given that today's youth are extremely connected to social networks 79,2% have never or rarely published posts on social media about environmental causes.

In general, young respondents perform well in the survey but also present opportunities to improve their behavior, attitudes and knowledge regarding the topics covered. Although attitudes score excellent in most cases, the actions do not always accompany them, so tools to support better performances and greater interventions are desirable. Building upon the solid foundation provided by OpenSimulator, the development team designed a suite of educational simulations aimed at embedding key sustainability and environmental concepts within interactive 3D virtual worlds (3DVW). These simulations were engineered to leverage experiential learning, employing immersive, scenario-based activities that place users in various situations where their decisions have direct implications on environmental outcomes. Through engaging in these virtual experiences, users are prompted to apply critical thinking and problem-solving skills, mirroring the complexities of real-world environmental management and personal responsibility towards sustainability.

The design approach for these simulations utilized branching scenarios, a storytelling method that offers users multiple pathways based on their decisions, to simulate the consequences of their actions in a virtual setting (Siordia-Medina, 2020). This methodology not only makes the learning process more engaging but also personalizes the educational experience (Thongsri et al.2019), allowing users to see the direct impact of their choices. Such an approach was instrumental in conveying the intricate balance between daily human activities and their environmental footprints, as well as the strategic considerations involved in managing renewable energy resources. By integrating these themes within captivating

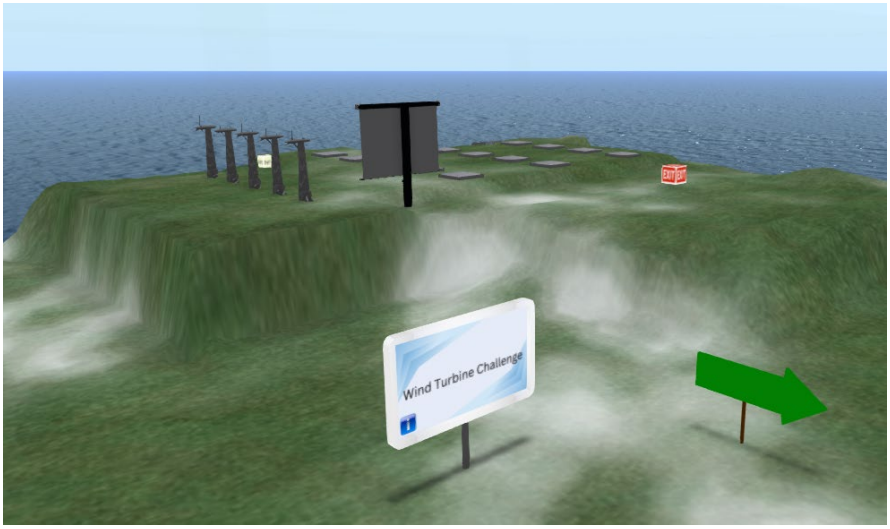
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

and interactive games, the simulations aimed to foster a deeper understanding of sustainability practices and encourage a reflective attitude towards personal and collective environmental impact.

A. Wind Farm Challenge

The "Wind Farm Challenge" scenario in the game (figure 1) is designed as an educational and interactive single-player simulation. This scenario aims to teach users about the aspects and challenges of wind energy production and wind farm management. The player takes on the role of a participant in the Wind Farm Challenge, where they are tasked with designing an efficient and sustainable wind farm within specific environmental and budgetary constraints. The game includes interactive elements such as discussions with Non-Player Characters (NPCs or 'bots') experts, a quiz on wind energy, and tasks that require critical thinking and decision-making based on environmental impact and technical considerations. The educational content is woven into the gameplay, providing an engaging learning experience about renewable energy and sustainability.

Fig. 1 – Educational scenario about wind energy - Wind farm challenge



Source: Elaborated by the authors (2024)

B. Carbon Champions

The "Carbon Champions" scenario is an educational game designed to teach players about carbon footprints and sustainable living (figure 2). Set in everyday environments like a home or school, players take on the role of a student making daily choices that impact their carbon footprint. The game features a carbon calculator that reflects the environmental impact of these choices. Players engage in activities like selecting meals, modes of transport, and energy use, each affecting their carbon footprint. The aim is to maintain a low carbon footprint, with the game providing feedback and information on how each choice contributes

BY-NC-SA 2024, Editorial Universitat Politècnica de València

to or mitigates climate change. This interactive and informative scenario encourages players to reflect on and adjust their habits for a more sustainable lifestyle.

Fig. 2 – Educational scenario about carbon footprint – Carbon champions



Source: Elaborated by the authors (2024)

C. Other Areas of the Environment

The 3D Virtual World (3DVW) comprises diverse virtual environments, each hosting a unique game (example in figure 3). These environments are populated with interactive 3D elements like doors and chairs, enabling avatar interaction. They also feature NPCs, which are computer-generated avatars participating in or enriching the scenarios. Additional features include text communication systems, user-friendly navigation, avatar performance monitoring, scoring mechanisms, feedback provision, tailored assistance, and methods for evaluating knowledge.

Fig. 3 - Educational scenario about recycling- Lost in the waste.



Source: Elaborated by the authors (2024)

Within the 3D Virtual World, the "Welcome Area" serves as a hub for users, featuring a scenario selection room where they can choose from 10 different environmental scenarios.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Each scenario is uniquely designed to raise awareness about a specific environmental issue. Additionally, there's a tutorial room where users learn basic game mechanics, such as movement and interaction with NPCs. This setup is structured to facilitate user engagement and education in various environmental topics through interactive and immersive virtual experiences. The 'in-world' textual content and the educational material of the 3DVW is produced and implemented in five languages: English, Greek, Italian and Portuguese.

4. Conclusions

To achieve the proposed goals, an innovative tool for teaching and learning practices was developed, changing learning techniques from teacher-centered to student-centered. Active learning helps students to rethink learning as a creative, engaging, and constructive process. The pedagogical tool, a 3Dimension Virtual World Learning Environment (3D VWLE), allows the simulation of activities with gamified elements that educate students through action; knowledge will be perceived not only through text, but through multiple modalities, while students' environmental awareness and knowledge will be reinforced by a visual perception as close to reality as possible. For the next steps, we expect to collect additional information from the players, in school and on laboratory environment, which will allow us to assess the effective impact of the tool on learning.

Acknowledgements

This project is co-funded by Erasmus+ Programme of European Union, action KA220-SCH Cooperation partnerships in school education, under the contract 2022-1-EL01-KA220-SCH-000088295. The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

An, Y. (2019). Creating Smart Learning Environments with Virtual Worlds. In Foundations and Trends in Smart Learning, M. Chang, E. Popescu, Kinshuk, N.-S. Chen, M. Jemni, R. Huang, J. M. Spector, and D. G. Sampson, Eds., in Lecture Notes in Educational Technology. Singapore: Springer Singapore, pp. 89–92. doi:10.1007/978-981-13-6908-7_12

Bransford, J.; National Research Council (U.S.), and National Research Council (U.S.), Eds., (2000). How people learn: brain, mind, experience, and school. Expanded ed. Washington, D.C: National Academy Press.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Gericke, N., Boeve-de Pauw, J., Berglund, T., & Olsson, D. (2019). The Sustainability Consciousness Questionnaire: The theoretical development and empirical validation of an evaluation instrument for stakeholders working with sustainable development. Sustainable Development, 27(1), 35–49. https://doi.org/10.1002/sd.1859

Grivokostopoulou, F; Kovas, K. & Perikos, I. (2020) The effectiveness of embodied pedagogical agents and their impact on students learning in virtual worlds. Appl. Sci., vol. 10, no. 5, p. 1739.

Lestari H, Ali M, Sopandi W, Wulan AR, Rahmawati I (2022). The Impact of the RADEC Learning Model Oriented ESD on Students' Sustainability Consciousness in Elementary School. Pegem Journal of Education and Instruction, Vol. 12, No. 2, 2022, 113-122

Lo, S -C. &Tsai, H-H. (2022). Design of 3D virtual reality in the metaverse for environmental conservation education based on cognitive theory. Sensors, vol. 22, no. 21, p. 8329.

Lombardo, T. (2009). Understanding and teaching future consciousness. Horiz., vol. 17, no. 2, pp. 85–97.

Maratou, V.; Xenos, M.; Granic, A.; Vuckovic, D. & Drecun, A. (2015). Enhancing Learning on Information Security Using 3D Virtual World Learning Environment. In 5th International Conference on Information Society and Technology, ICIST2015, pp. 279–284. Accessed: Feb. 01 (online)
Available:https://www.ceid.upatras.gr/webpages/faculty/xenos/papers/C099.pdf

Michalos, A. C., Creech, H., Swayze, N., Kahlke, M., Buckler, C., & Rempel, K. (2012). Measuring knowledge, attitudes and behaviors concerning sustainable development among tenth grade students in Manitoba. Social Indicators Research, 106(2), 2013–2038.

Siordia-Medina, P.R.; Uribe-Olivares, N.S. & González-Basilio, S. de J. (2020) Creation of environments and scenarios for learning based on internet habits: a theoretical approach for face-to-face, blended and distance education. J. Inf. Technol. Commun., pp. 4–13.

Thongsri, N.; Shen, L.; & Bao, Y. (2019) Investigating factors affecting learner's perception toward online learning: evidence from ClassStart application in Thailand. Behav. Inf. Technol., vol. 38, no. 12, pp. 1243–1258, Dec. doi:10.1080/0144929X.2019.1581259

Unesco (2022). Youth demands for quality climate change education. Published by the United Nations Educational, Scientific and Cultural Organization, 7, Place de Fontenoy, 75352 Paris 07 SP, France. https://unesdoc.unesco.org/ark:/48223/pf0000383615

2024, Editorial Universitat Politècnica de València BY-NC-SA

Empowering Small and Medium-sized Enterprises for Business Growth

Anna Ollanketo[a], Mervi Rajahonka[a] and Heli Saali[a]

[a]Digital Economy, South-Eastern Finland University of Applied Sciences, Finland

Abstract

The significant obstacles for small and medium-sized enterprises (SMEs) to utilise the benefits of digital technologies include a deficiency in the skills and expertise of employees and a limited understanding of the potential of digitalisation. The purpose of the paper is to explore these challenges and how they can be addressed with training. The paper presents a case study from the South Savo region, Finland, where an experimental training model was developed and tested in a project aiming to enhance the digital skills of SMEs. Our research questions are: 1) What were the digital training needs and skills gaps in SMEs? 2) How can the project's training model be applied to other contexts, such as the green transition? To answer these questions, firstly, the project's training model is presented. Developing the training model involved identifying the digital competences relevant to each SME. Subsequently, customised short training courses, coaching, and extended training paths were provided to the SMEs. Secondly, the participating SMEs' most significant digital training needs and skills gaps are discussed. These included digital advertising, online visibility, digital content production, and social media. Finally, the paper discusses how the model used in the project can be adapted to any other training needs, for example, related to green or twin transitions.

Keywords: *digital skills; SMEs; training model; Finland; competence mapping.*

How to cite: Ollanketo, A.; Rajahonka, M. and Saali, H. (2024) Empowering Small and Medium-sized Enterprises for Business Growth. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 655-663. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

It has been claimed that only 17% of small and medium-sized enterprises (SMEs) in the European Union (EU) have succeeded in integrating digital technologies into their business operations (European Commission, 2020; Depaoli et al., 2020; Rajahonka et al., 2023). The significant obstacles for SMEs to utilise the benefits of digital technologies include a limited understanding of the potential of digitalisation and a deficiency in the skills and expertise of employees. (DESI, 2022.) Addressing these challenges and achieving the objectives will require a substantial increase in the support and training provided to SMEs (Rajahonka et al., 2023).

At the same time, green and digital (twin) transitions are at the highest level in the political agenda of the European Union (EU). The EU aims to employ digital technologies to deliver sustainability and considers the twin transitions as key to delivering a sustainable future (Muench et al., 2022). Delivering both transitions will demand enormous actions for the future. Until now, the advancements in digital technology have paid limited attention to sustainability. The green and digital transitions are fundamentally different in nature, but it is important to discuss how they could support each other; so that any negative or unforeseen effects of digitalisation can be prevented, and its full potential realised. (European Commission 2022.)

It is clear that the twin transitions will have substantial effects on the skills demanded in the future. For companies and their employees learning new skills and competences is necessary to adapt to this new situation. (European Commission 2022.)

In the EU, there are ongoing attempts to specify the skills needed in the future labour market. For the categorisation of digital competences, the European Digital Competence (DigComp) Framework for Citizens has been developed since 2013 by the European Commission (EC). Digital competence areas have been defined in the DigComp 2.2 framework as 1) Information and data literacy; 2) Communication and collaboration; 3) Digital content creation; 4) Safety; and 5) Problem-solving. Since 2015, the EC has used the Digital Skills Index (DSI) based on DigComp to follow the progress of citizens' digital skills. (Vuorikari et al., 2022; Rajahonka et al., 2023.)

The development work of the new GreenComp framework is an important part of the policy actions defined in the European Green Deal. GreenComp comprises four competence areas: embodying sustainability values, embracing complexity in sustainability, envisioning sustainable futures, and acting for sustainability. (Bianchi et al., 2022.) These efforts are still in development and will likely require additional work in the future.

The use of digital technologies in companies has been measured with the Digital Intensity Index (DII) at the EU level by counting how many out of 12 selected technologies are used.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

These 12 technologies are: having fast fixed-line internet connection of at least 30 Mb/s, using any social media or at least two social media, any cloud service or intermediate-sophisticated cloud computing services, ERP software package, CRM, any IoT, any AI technology, more than half of employees using computers with access to the internet for business purposes, having e-commerce sales of at least 1% turnover or web sales more than 1% of the total turnover and B2C web sales more than 10% of the web sales. (DESI, 2022).

Concerning digitalisation, the situation in Finland is, in many ways, excellent. In 2021, Finland held second place in the EU, measured by digitalised SMEs, with over 82% of Finnish SMEs having at least a basic level of digital intensity. Finland held first place, however, with its citizens' digital skills, with 79% of people possessing at least basic digital skills. In addition, the country reached second place in digital public services. Even though Finland is an EU forerunner, it has been acknowledged that for forerunners, challenges in digitalisation still persist. When comparing, for example, SMEs selling online or their online cross-border sales, the relative position of Finnish SMEs is inferior. (DESI, 2022.) This shows that Finnish SMEs also have difficulties in turning these competences into business success.

The present study discusses the challenges in SMEs' digital development and describes the results and observations of an experimental model created, developed, and tested in a project that aimed to increase SMEs' digital skills in the South Savo region, Finland. Our research questions are: 1) What were the digital training needs and skills gaps in SMEs? 2) How can the project's training model be applied to other contexts, such as the green or twin transitions? The rest of the paper is organised as follows. First, we briefly describe the background of the project and the model and methods developed. After that, we outline the results and observations. Finally, we discuss the adaptability of the model and present concluding remarks.

2. Project background

In the South Savo region, the number of SMEs per inhabitant is the second highest in Finland. At the same time, the proportion of inhabitants over 65 years old is the highest, and the education level of the working-age population is lower than the national average. The SMEs in the region typically operate in traditional industries and the primary employer is the service sector. There are only a few growth companies in the region. (The Regional Council of South Savo, 2022.)

The focus of the project was meeting the business needs of SMEs in the South Savo region by improving the digital skills of the entrepreneurs and SMEs' employees and supporting the companies to achieve business growth. The project's model relied on a competence mapping survey conducted with every SME involved. This survey identified the most crucial digital competence areas for achieving business success and pinpointed the corresponding skills

BY-NC-SA 2024, Editorial Universitat Politècnica de València

gaps. The survey questions were developed based on a comparative analysis of similar surveys conducted in Finland and the EU combined with project personnel's experiences in previous projects and discussions with knowledgeable business advisors. For example, DigComp is intended to measure competences at the level of an individual, and DII uses indicators based on the usage of digital technologies at the company level. The participating SMEs in the project were small, and most only consisted of an entrepreneur or a maximum of one or two other persons. These companies represented various fields e.g., retail, small-scale industries, hospitality, and health services. Therefore, the competence questionnaires had to be adapted to these particular target groups.

The selected competence areas inspected in the survey questionnaire were: 1. Basic competences, improving work efficiency through digitalisation, 2. Digital information management and information security, 3. Producing online content, 4. Online visibility, 5. Digital advertising, 6. Social media, 7. Online retail and digital sales, 8. Internal production management, 9. Data collection, analysis, and utilisation. Each of these nine areas consisted of sub-sections, and the questionnaire consisted of a total of 48 competence areas. Furthermore, the respondents were able to record any additional skill need not covered among the listed competences.

In the next section, we will discuss the model more thoroughly, along with some of the preliminary observations and results of the project.

3. The training model

The project started with each SME with a competence mapping process, conducted through a meeting with a business advisor and a representative from the SME, utilising a survey questionnaire encompassing 48 competence areas. During the meeting, the business model of the company and its training needs were discussed. Subsequently, each SME was provided with a tailored action plan and syllabus derived from the mapping, leading to enrolment in relevant short or longer training courses and the utilisation of business coaches' expertise. Most of the short training courses arranged in the project were taught by outsourced trainers with up-to-date knowledge of the digital tool or digital business model in question. The training model is described also in our previous paper (Rajahonka et al., 2023).

The training calendar was built based on the SMEs' business model and needs, and each short training was tailored based on participants' competence levels defined either as basic or advanced. The COVID-19 pandemic forced the project to offer courses online, but later participants' feedback showed there was a need for on-site training to support peer learning and sharing of participants' experiences. Training occurred in small groups, adapting new

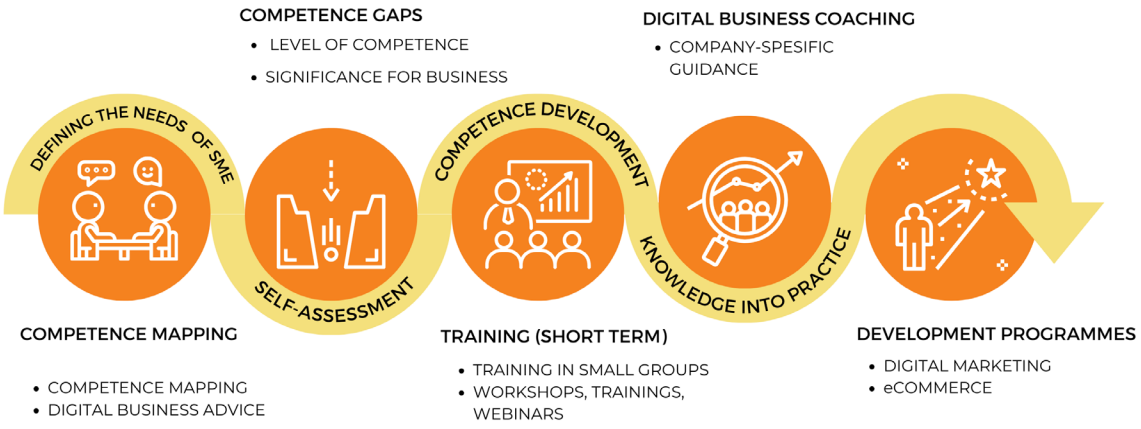
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

digital tools and strategies emphasising learning by doing learning methods. Company-specific and focused coaching was provided as a small-scale service.

In addition to competence mappings, participants were offered an option to follow their personal development with self-assessments, where the same competence areas were covered as in the competence mapping interview. The participants were given the chance to answer the questionnaire several times throughout the project, enabling them to monitor the progression of their competences. The option for self-assessment was extended to multiple staff members within the company, not exclusively to the entrepreneur. (Rajahonka et al., 2023.)

The training model prioritised hands-on support, practical skills, and peer learning, with online resources such as blogs, publications, and guides to support learning and applying new skills and tools. Furthermore, individualised coaching tailored to each company was offered, along with more advanced and extended training programs, such as digital marketing and e-commerce development programs. (Rajahonka et al., 2023; Kosonen et al., 2023.) The training model of the project is delineated in Figure 1.

Figure 1. The training model of the Digital Steps 2.0 project



Source: adapted from Rajahonka et al. (2023).

4. Results and observations

Table 1 illustrates the competence areas and the most common training needs within each area, along with the prevalence among 176 respondents, and the average competence gap sizes based on self-assessments from 82 individuals. The prevalence of training needs is presented in percentages, and the extent of skill gaps is indicated on a scale of 0-5.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 1 - Competence areas and gaps

Competence area	Examples of prevalent training needs within competence areas	Prevalence of training need (N = 176)	Self-assessed competence gap, 0-5 scale (N=82)
Digital advertising	Email marketing, ad-creation, Facebook Business Manager	90%	2,0
Online visibility	SEO, WordPress, Google My Business	81%	2,0
Producing online content	Graphic content creation, video-editing, online writing	81%	1,6
Social media	Instagram, Facebook, YouTube	72%	1,5
Data collection, analysis, and utilisation	Google Analytics	67%	1,7
Online retail and digital sales	Conversion rate optimisation, customer journey	61%	1,5
Basic competences and work efficiency	Office software, project management tools	41%	0,9
Digital information management and information security	GDPR, cloud services	35%	1,3
Internal production management	Customer relationship management	25%	1,0

Source: The Digital Steps 2.0 project (2023)

In the competence mappings between September 1, 2021, and August 30, 2023, the most common training need identified by 90% of the enterprises was digital advertising. The second most common competence need was online visibility and producing online content, both identified as training needs by 81% of the SMEs. Similarly, the most significant skill gaps based on self-assessment tests were in digital advertising and online visibility.

The competence gaps were calculated in all nine competence areas (and any extra areas defined by the respondent) based on the self-assessment tests. In the test, the respondent assessed their competence level and the significance of the subject area for the company's business on a scale of 1-5. The difference between these dimensions was used to calculate the competence gaps; if, for example, the respondent assessed the significance of the subject area as 5, and the competence as 3, the gap was 2,0. For example, the most notable average competency gaps were identified in digital advertising and online visibility, with a gap of 2.0 in both areas. (See Table 1.)

5. Discussion and conclusion

Most employees and entrepreneurs have not learned digital skills at school. Furthermore, as everyday work life is continually changing, digital competences need constant monitoring

 BY-NC-SA

and updating. Only in this way, can it be ensured that SMEs are trained in the needed competence areas to grow and develop their business. (Kosonen et al., 2023.)

The model created in the project provided the essential tools for SMEs to enhance their digital skills. The training model involved identifying the digital competences relevant to each SME along with the level of their current skills in these competence areas. Grounded in the discovered competence gaps, a syllabus for each SME was devised to address and bridge these gaps. Tailored to their individual needs, the training initiatives included a variety of support services such as training, coaching, and targeted training programs. (Rajahonka et al., 2023.)

Since the training sessions were mostly practice-oriented and contained concrete advice for SMEs, and the most relevant areas of digital competences and a syllabus were customised for each SME, most of the SMEs in the project could use the lessons learned directly in their own business. This could be seen in the training and coaching feedback. (Kosonen et al., 2023.)

Green skills are essential to reduce environmental impacts and facilitate the restructuring of the economy toward a cleaner, climate-resilient economy and environment, along with decent work conditions (Koundouri et al., 2023). Although until now, digitalisation and sustainability have seen separate, digitalisation can support efficiency and sustainability in many sectors, for example in agriculture, buildings and construction, energy, energy-intensive industries, and transport and mobility. For example, in the energy sector, digital technologies facilitate efficient communication and optimisation within an increasingly complex energy system. (Muench et al., 2022.)

To deliver a sustainable future, the twin transitions demand new attitudes and actions in SMEs in their digital business. The actions can be, for example, ecological efficiency when designing website structures. According to Turunen (2022), easily discoverable content, logically functioning links, and the simplification of content contribute to the reduction of unnecessary page loading, thereby mitigating the energy consumption associated with website usage. Further, virtual collaboration tools reduce the need for physical office spaces and travel, promoting remote work and reducing the carbon footprint of employees and companies. Within online commerce, enhancing the user experience on the webstore and providing detailed information, like clothing sizes, reduces the frequency of product returns and decreases the shipping volume. In addition, e-tailers should put a greater emphasis on the sustainability of products, instead of shipping low-cost production overseas.

The model used in the project in South Savo for developing digital competences of SMEs can be rather easily adapted to any other training needs, for example competences related to green or twin transitions, by following the steps used in the project. The steps are the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

following: 1) Build a framework for competences to test, for example, based on GreenComp competence areas, namely sustainability values, complexity in sustainability, visions of a sustainable future, and acting for sustainability (Bianchi et al., 2022.); 2) Define the relevant competence areas for each SME along with the level of their current skills in these areas; 3) Draft a customised syllabus to overcome these gaps for each SME; 4) Based on the needs, organise training and coaching for SMEs. Continuous evaluation ensures the effectiveness of the training and promotes continuous improvement in line with the evolving needs, for example, in green or twin transitions based on the European Green Deal objectives.

Acknowledgments

'Digital Steps 2.0 - Paths for business growth' (2021-2023) was funded by the South Savo Centre for Economic Development, Transport, and the Environment, and the European Social Fund, React EU Funds. The project partners were South-Eastern Finland University of Applied Sciences (Xamk), Mikkeli Development Miksei Ltd, Savonlinna Development Services Ltd, and ProAgria Southern Savonia.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bianchi, G., Pisiotis, U. & Cabrera Giraldez, M. (2022). GreenComp – The European sustainability competence framework. Bacigalupo, M. & Punie, Y. (editors). *Publications Office of the European Union.* ISBN 978-92-76-46485-3, doi:10.2760/13286, JRC128040.

Depaoli, P., Za, S., & Scornavacca, E. (2020). A model for digital development of SMEs: an interaction-based approach. *Journal of Small Business and Enterprise Development*, 27(7), 1049-1068. https://doi.org/10.1108/JSBED-06-2020-0219

DESI. Digital Economy and Society Index 2022. (2022). Thematic chapters. https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission. (2020). Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: An SME Strategy for a sustainable and digital Europe, COM/2020/103 final.

European Commission. (2022). Communication from The Commission to The European Parliament and The Council: 2022 Strategic Foresight Report. Twinning the green and digital transitions in the new geopolitical context. COM (2022) 289 final.

Eurostat News. (2022). How digitalised are the EU's enterprises? https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220826-1

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Koundouri, P., Landis, C., Toli, E., Papanikolaou, K., Slamari, M., Epicoco, G., Hui C., Arnold, R., Moccia, S. (2023). Twin Skills for the Twin Transition: Defining Green & Digital Skills and Jobs. AE4RIA, ATHENA Research Centre, Sustainable Development Unit.

Kosonen, M., Rajahonka, M. & Saali, H. (2023). Digitalization in Small and Medium Enterprises: Lessons from the Digital Steps Project. IN: Jääskeläinen, P. & Weaver, C. *Xamk Beyond 2023: Digitalization.* Xamk Research, ISSN: 2489-2459, 27, pp. 10-27.

Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. & Scapolo, F. (2022). Towards a green and digital future. Publications Office of the European Union. Luxembourg. ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319.

Rajahonka, M., Ollanketo, A., Saali, H. & Kiukas, A.-M. (2023). Model for Digital Skills Training for SMEs, IN: Moreira, F. & Jayantilal, S. (eds.) *Proceedings of the 18th European Conference on Innovation and Entrepreneurship*, 21-22 September 2023, 18(2):739-745. DOI:10.34190/ecie.18.2.1735

Turunen, J. (2022). Suunnitteluvirheet voivat moninkertaistaa verkkosivun hiilijalanjäljen (Design flaws can multiply the carbon footprint of a website). *Xamk Next*. https://next.xamk.fi/vastuullisesti/suunnitteluvirheet-voivat-moninkertaistaa-verkkosivun-hiilijalanjaljen/

The Regional Council of South Savo. (2022). Statistics. https://www.esavo.fi/tilastot

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

What is the best way to communicate with students? An ordered logit regression approach for the study of communication between e-tutors and students in an Italian online University

Giorgio Cecchi[a], Andrea Nardi[a] and Massimiliano Naldini[a]

[a]Università Telematica degli Studi IUL, Italy

Abstract

The COVID-19 pandemic has heightened the significance of tutors in online education, as they offer essential support to students, including guidance, technological assistance, and instructional help. Recognizing their crucial role in ensuring successful online learning experiences, this study offers initial insights from ongoing research at an Italian Telematic University, specifically on tutoring. The project aims to analyse the e-tutor community's composition and practices, including roles, student relationships, teaching methods, platform tool usage, and orientation strategies. The results presented in this paper are based on a questionnaire administered to (n=57) e-tutors. The questionnaire covers various dimensions, including the educational background of e-tutors, their professional experiences, perceptions, and expectations, as well as their competencies in disciplinary, methodological, and socio-relational aspects. Responses were collected using a 4-point Likert scale, indicating the frequency of certain tasks as "Frequently," "Sometimes," "Rarely," or "Never." The study specifically focuses on the frequency with which tutors use certain tools to communicate with students and aims to assess the association between these items and sociodemographic and academic characteristics of the tutors using an Ordered Logistic Regression Model. The significant results obtained from ordered regression analyses are that male tutors prefer group communication tools more than females, while females prefer one-to-one communication tools more than males. In addition, as age increases, it is noticeable that one-to-one communication tools are preferred by tutors.

Keywords: E-learning; MOOC; E-tutoring; Online higher education; Ordered Logit Regression.

How to cite: Cecchi, G.; Nardi, A. and Naldini, M. (2024) What is the best way to communicate with students? An ordered logit regression approach for the study of communication between e-tutors and students in an Italian online University. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 664-671. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The Covid-19 pandemic has brought back the focus on distance learning and actions to support students' learning in online environments. If traditional universities had to adapt their format (Biasi et al., 2022), telematic universities had the opportunity to reflect on important educational aspects, such as tutoring (Ferrari et al., 2021; Raviolo, 2020). Over the last decades, this professional figure has been the focus of a wide and fruitful reflection that starting from the concept of modelling (Salomon, 2003) has aimed to define roles, functions, styles, knowledge, and skills (Bonaiuti, 2006; Calvani, 2009; Ranieri, 2011). In the university under study, the focus has been on the mentoring model, on the peculiar characteristics of this role and on how to improve them. In a context of Community of Inquire (Benedetti, 2018), the figure of the tutor straddles the three dimensions: teaching presence, social presence, cognitive presence (Mori and Baldi, 2023). The goal of the tutor is to guide the student in his formative path and at the same time support the motivation of students by putting into play not only methodological/disciplinary skills but also social, emotional and technological guaranteeing the autonomy of the learner and his full participation in the processes of building knowledge (Abdullah and Mtsweni, 2014; Berge, 1992).The e-tutor must possess a rich variety of communication techniques in line with the strengths, beliefs and requirements of the e-tutor's context (Ferrari and Triacca, 2021). A specific trait lies in the management of synchronous and asynchronous communication, an essential prerogative of networked training, which incorporates the set of positions taken in the interactions between participants and the varied forms of messaging to support the initial, in itinere and concluding activities, increasingly reducing the social distance between the actors involved (Maré and Mutezo, 2020).

In 2022, research was launched to collect data on the community of tutors and their practices, behaviours and relationships both within the professional community and towards students. The purpose of the study is to collect data to map the role of e-tutor identifying the practices in support of the student but also to know the characteristics and dynamics of the practice community useful for professional satisfaction and success (Guan and Frenkel, 2018; Kang and Yang, 2016; Lounsbury et. al., 2007).

2. Methodology

The objective of this study is to use a mixed method design to obtain superior conclusions from diverse data sources, improve the reliability of the findings, and gain a deeper comprehension of phenomena. Surveys and questionnaires were used to map the community, while focus groups and interviews were used to deeply listen to the perceptions, needs, preferences, and habits of the community.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The information forming the basis of this research was gathered through a CAWI (Computer Assisted Web Interview) questionnaire disseminated among the complete University e-tutor community, resulting in 57 respondents out of a total of 108. Before its official administration, the questionnaire underwent a pre-test phase (Bowden et al., 2002), during which it was evaluated by 7 seasoned tutors who are part of the University community. The survey explores various aspects and facets, including the e-tutor's interests, educational and cultural history, prior professional experiences, perceptions, and expectations regarding their role. It also delves into disciplinary, methodological, and socio-relational competencies, as well as the tutor's styles, practices, and strategies. For the analysis, the section of the tools preferred by e-tutors for communication, inside and outside the LMS (Learning Management System) platform with students was considered. The question in the questionnaire is as follows:

"Thinking about your last tutoring assignment, how often did you interact with students in the following ways?"

For which the following sub-questions are provided:

- "On the LMS platform synchronously in a group".
- "On the LMS platform in an individual synchronous manner".
- "On the LMS platform through collective messaging".
- "By e-mail".

All responses are conveyed using a four-point frequency Likert scale, featuring the following labels: "Frequently", "Sometimes", "Rarely", "Never".

As a first step, a Spearman correlation analysis was conducted to verify whether on average, a greater use of certain tools was associated with a greater or lesser use of others.

Secondly, to evaluate the association between the use of certain communication tools and some sociodemographic and academic characteristics of the tutors, ordered logit regression models were implemented using the statistical software STATA 18.

The ordered logit model relies on the cumulative probabilities of the response variable: specifically, it assumes that the logit of each cumulative probability is a linear function of the covariates, with regression coefficients remaining constant across response categories (Agresti, 2010).

An ordinal logit model for an ordinal response variable Y_i, which has C categories, is characterised by a series of $C\text{-}1$ equations. These equations relate the cumulative probabilities $g_{ci}=Pr(Y_i \leq y_c | x_i)$ to a linear predictor $\beta' x_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots$ via the logit function:

$$logit(g_{ci}) = log(g_{ci} / (1-g_{ci})) = \alpha_c - \beta' x_i, \qquad c=1,2 \ldots C\text{-}1 \tag{1}$$

BY-NC-SA

Where:

α_c are parameters called thresholds increasing ordered ($\alpha_1 < \alpha_2 < \ldots < \alpha_{C-1}$)

β' is the vector of the slops which is not indexed by the category index c, thus the effects of the covariates are constant across response categories

x is the vector of the independent variables.

The vector of independent variables is composed as follows:

X_1: age class

X_2: dummy variable for gender (male vs female)

X_3: dummy variable for University Master's degree (no vs yes)

X_4: dummy variable for Doctoral degree (no vs yes)

$X_5 \ldots X_8$: dummy variables for the type of degree (except for the baseline category "Psychology and Pedagogy").

3. Results

The descriptive statistics for the characteristics of the tutors used as independent variables in the ordered logit regression models are presented in Table 1.

Table 1 – Descriptive statistics for the sample of IUL tutors in the academic year 2022/2023

		n	%
Age class			
	≤30	8	14,1
	31-40	20	35,1
	41-50	19	33,3
	>50	10	17,5
Gender			
	Male	22	38,6
	Female	35	61,4
Type of degree			
	Psychology and Pedagogy	21	36,8
	Humanistic	14	24,6
	Scientific	6	10,5
	Mathematics	5	8,8
	Economics and Law	11	19,3
University Master's degree			
	No	37	64,9
	Yes	20	35,1
Doctoral degree			
	No	46	80,7
	Yes	11	19,3
Total		57	100,0

Source: Data processing of the IUL e-tutor questionnaire (2023-2024)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

As observed from Table 1, nearly two in three tutors are females and approximately half of them is between the ages of 24 and 40 (Min age = 24; Max age = 70; Median age = 41; Mean age = 41,4; SD = 10,12).

The frequency distributions of the questions used as dependent variables in the ordered logit regression models are shown in Table 2.

Table 2 – frequency distributions for each sub-question of the main question "Thinking about your last tutoring assignment, how often did you interact with students in the following ways?" (Percentages in parentheses)

	On the LMS platform synchronously in a group	On the LMS platform in an individual synchronous manner	On the LMS platform through collective messaging	By email
Frequently	33 (57,9)	9 (15,8)	17 (64,9)	21 (36,8)
Sometimes	20 (35,1)	17 (29,8)	15 (26,3)	18 (31,6)
Rarely	2 (3,5)	16 (28,1)	2 (3,5)	12 (21,1)
Never	2 (3,5)	15 (26,3)	3 (5,3)	6 (10,5)

Source: Data processing of the IUL e-tutor questionnaire (2023-2024)

Spearman's correlation analysis finds no significant associations, except for the slightly positive one between "On the LMS platform in an individual synchronous manner" and "On the LMS platform through collective messaging" (Spearman's ρ = 0,293; P-value =0,02).

The results of ordered logit models of the four items are reported in Table 4.

For an easier understanding of the results, odds ratios are reported instead of β coefficients.

The odds ratio (OR) signifies the ratio between the probability of a specific category of the independent variable resulting in a higher rank of the ordinal category outcome variable compared to the probability of the reference category of the independent variable leading to a higher rank of the ordinal dependent variable. In essence, an OR > 1 suggests that the category is more inclined towards holding a positive attitude.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Table 4 – Ordered logit regression models for each item. Odds ratios estimates. (Standard errors in parentheses, * P-values <0,05)

		On the LMS platform synchronously in a group	On the LMS platform in an individual synchronous manner	On the LMS platform through collective messaging	By email
Age class		0,221* (0,102)	0,984 (0,286)	1,513 (0,649)	1,578 (0,501)
Gender					
	Female	0,068* (0,060)	1,768 (0,991)	1,018 (0,660)	7,180* (4,347)
Type of degree					
	Humanistic	21,900* (24,814)	0,736 (0,556)	0,230 (0,228)	4,262 (3,420)
	Scientific	0,102 (0,121)	0,901 (0,816)	0,178 (0,184)	0,384 (0,366)
	Mathematics	0,087* (0,105)	0,569 (0,523)	0,606 (0,822)	1,367 (1,365)
	Economics and Law	0,950 (0,790)	0,428 (0,300)	0,111* (0,098)	0,680 (0,481)
University Master's degree					
	Yes	0,805 (0,617)	2,023 (1,260)	0,573 (0,405)	0,278* (0,172)
Doctoral degree					
	Yes	1,575 (1,285)	1,024 (0,657)	0,306 (0,237)	2,395 (1,640)
Thresholds					
	Never	-9,809 (2,146)	-0,820 (1,040)	-3,779 (1,400)	-0,625 (1,140)
	Rarely	-8,955 (2,056)	0,471 (1,033)	-3,205 (1,346)	1,225 (1,161)
	Sometimes	-5,724 (1,710)	2,029 (1,078)	-1,191 (1,287)	3,060 (1,202)
Likelihood ratio χ^2 (8)		27,460	5,200	11,85	26,65
Pseudo R^2		0,262	0,034	0,115	0,180

Source: Data processing of the IUL e-tutor questionnaire (2023-2024)

The effects are significant in terms of age, gender, and type of degree. As age increases, tutors are on average less inclined to use synchronous group communication tools frequently. In addition, these tools are used less frequently by females, who instead use e-mails much more, for females in fact the risk of using emails more frequently is 7 times higher than for males. Synchronous group communication tools are also much more used by tutors with a degree in the humanities (OR = 21,9) than those with a degree in pedagogy and psychology, while they are much less used by tutors with a degree in mathematics. The model fit indices, Likelihood Ratio χ^2, and pseudo R^2 align with the similar study conducted by Liao et al. 2022.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Conclusions

The study discusses the role of e-tutors in the context of distance learning. Tutors play a crucial role in supporting students' learning experiences in online environments, especially as traditional universities and telematic universities alike adapt to new formats. The emphasis on tutoring reflects a growing recognition of the importance of personalised support for students navigating virtual learning spaces. The preferred communication tools among tutors for interacting with students are group synchronous modalities and collective messaging. These methods allow for direct and immediate interaction with the entire group, facilitating discussion, idea exchange, and real-time doubt resolution. However, it's noteworthy that gender differences influence the choice of communication tools among tutors. Female tutors tend to use emails more than males, while males prefer utilising group synchronous communication tools more frequently than females. Additionally, it's observed that as tutors age, there's a tendency to use group synchronous communication tools on platforms less frequently.

Conversely, individual synchronous modalities within platforms are considered less preferred by tutors. Instead, for individual communications, tutors have expressed a clear preference for using emails. This method offers greater flexibility and allows for more personalised and detailed communication with students, enabling them to address specific issues in a more thorough manner.

As limitations, the study's sample size may limit the generalizability of findings, particularly considering the diverse backgrounds and contexts of e-tutors in different educational institutions; moreover, the study focuses on a specific university context, which may not fully capture the varied needs and preferences of tutors and students across different educational settings. In conclusion, the analysis emphasises the fundamental role of communication tools in facilitating interactions between tutors and students in online learning contexts. Although the study reveals important associations between tool usage and demographic and academic characteristics, more research is needed to validate these findings in different contexts and explore additional factors influencing communication dynamics.

Acknowledgements

The research was funded by Università Telematica degli Studi IUL.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València BY-NC-SA

References

Abdullah, H., & Mtsweni, J. (2014). The role of e-tutors in promoting e-learning using Web 2.0 technologies. African Cyber Citizenship Conference. Port Elizabeth, South Africa. http://hdl.handle.net/10204/7943

Agresti, A. (2010). Analysis of Ordinal Categorical Data, 2nd edition. John Wiley & Sons. https://doi.org/10.1002/9780470594001.ch3

Biasi, V., De Vincenzo, C., Nirchi, S., & Patrizi, N. (2021). La didattica universitaria online ai tempi del Covid/19: rilevazione di aspettative, punti di forza e criticità. In G.C.V. Carbone (Cur.), Ricerca Dipartimentale ai tempi del Covid-19 (147-159). RomaTrE-Press. https://doi.org/10.13134/979-12-5977-021-9

Bonaiuti, G. (2006). E-Learning 2.0. Il futuro dell'apprendimento in rete, tra formale e informale. Erickson. https://hdl.handle.net/11584/25594

Bowden A., Fox-Rushby J.A., Nyandieka L., & Wanjau, J. (2002). Methods for pre-testing and piloting survey questions: illustrations from the KENQOL survey of health-related quality of life. *Health Policy and Planning*, 17(3), 322–330. https://doi.org/10.1093/heapol/17.3.322

Calvani, A. (2009). Dall'educazione a distanza all'e-learning. Enciclopedia Treccani. https://bit.ly/3lE104x

Ferrari, S., Mauro, I., Messina, S., Raviolo, P., & Rivoltella, P.C. (2021). E-tutoring nella didattica telematica. Pratiche di modellamento. *Excellence and Innovation in Learning and Teaching, 6, 113-125*. https://doi.org/10.3280/exioa0-20210a11131

Ferrari, S., & Triacca, S. (2021). The Strategic Role of the E-Tutor in New Learning Contexts. In Agrati, L., Burgos, D., Ducange, P., Limone, P., Perla, L., Picerno, P., Raviolo, P., Stracke, C. (eds) Bridges and Mediation in Higher Distance Education (300-314), Springer International Publishing, Switzerland AG. https://doi.org/10.1007/978-3-030-67435-9_23

Liao, Y., Zhou, H., Wang, F., Zhao, M., Wu, J., & Rong, P. (2022). The impact of undergraduate tutor system in Chinese 8-year medical students in scientific research. *Frontiers in Medicine*, 9, 854132. https://doi.org/10.3389/fmed.2022.854132

Maré, S., & Mutezo, A.T. (2020). The effectiveness of e-tutoring in an open and distance e-learning environment: Evidence from the university of South Africa. *Open Learning: The Journal of Open, Distance and e-Learning*, 36(2), 164-180. https://doi.org/10.1080/02680513.2020.1717941

Mori S. & Baldi G. (2022). L'apprendimento collaborativo nei corsi universitari online. IUL Press.

Ranieri, M. (2011). Le insidie dell'ovvio, Tecnologie educative e critica della retorica tecnocentrica. ETS.

Raviolo, P. (2020). Interazioni e-tutor-studenti e successo formativo: un'analisi dei dati nel contesto dell'educazione superiore online. *Excellence and Innovation in Learning and Teaching*, 5(2), 56-67. https://journals.francoangeli.it/index.php/exioa/article/view/10810

Rivoltella, P.C. (2006). E-tutor. Profilo, metodi, strumenti. Carocci, Roma.

Salmon, G. (2003). E-moderating: The key to teaching and learning online. Routledge.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Failures of Education Policy Reforms to Address Climate Change

Donal E. Mulcahy [a]**; Judith Madera** [b]

a Education Department, Wake Forest University, USA aInstitute/Department, Name of Institution, Country

b English Department, Wake Forest University, USA

Abstract

In this paper we look at U.S. education policy reforms of recent decades and their impact on environmental education, in particular regarding climate change Throughout this period, policymakers have not only prioritized standards-based schooling but have pursued it at almost any cost. Curricular decisions, during this time, have increasingly moved into the hands of legislatures, and further from those of educators. Despite the warnings of educators, what we term the Super Constituency (SC) (entities in society that are represented by the government over the rightful democratic constituency, (Mulcahy, forthcoming)) has had an outsized effect on educational policy over the past 30 years. As a result, school curricula have also become increasingly politicized. In the United States, this has meant not only shying away from teaching the scientific and social realities of climate change, but almost completely avoiding them. To date, there are no national requirements for High School students to learn about climate change. Among the 50 states, only 2, New Jersey and Connecticut, require that climate change be taught in public schools (Madelone, 2023).

Keywords: Education Policy; Environmental Education; Standards; Critical Pedagogy.

How to cite: Mulcahy, D. and Mader, J. (2024) Failures of Education Policy Reforms to Address Climate Change. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 672-678. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In this paper we look at U.S. education policy reforms of recent decades and their impact on environmental education, in particular regarding climate change Throughout this period, policymakers have not only prioritized standards-based schooling but have pursued it at almost any cost. Curricular decisions, during this time, have increasingly moved into the hands of legislatures, and further from those of educators. Despite the warnings of educators, what we term the Super Constituency (SC) (entities in society that are represented by the government over the rightful democratic constituency, (Mulcahy, forthcoming)) has had an outsized effect on educational policy over the past 30 years. As a result, school curricula have also become increasingly politicized. In the United States, this has meant not only shying away from teaching the scientific and social realities of climate change, but almost completely avoiding them. To date, there are no national requirements for High School students to learn about climate change. Among the 50 states, only 2, New Jersey and Connecticut, require that climate change be taught in public schools (Madelone, 2023).

For a broader context of who has controlled education policy, I will briefly examine some of the arguments and hopes of both educators and representatives of the Super Constituency (SC). Organizations such as the Broad Foundation, the Heritage Foundation the Fordham Foundation, now the Fordham Institute, and the American Legislative Exchange Council (ALEC) are some examples. They have had a huge influence on the curricular standards that have been written and mandated over the past few decades. Chester Finn and Diane Ravitch are example of Foundation members who served under Reagan and Bush 1 and helped to draw up the very standards issued. Because of the conflict between the ideological and/or economic goals of their members, donors or affiliates, and an environmental education, the standards they have fought tirelessly for have had little to no emphasis on the environment and in particular, the climate.

2.Disempowering Teachers Through Standardization

From America 2000 under Bush 1 and Goals 2000 under Clinton to No Child Left Behind under Bush 2, the standardization of the U.S. curriculum that occurred in different iterations over the past 30-plus years, increasingly delineated what teachers were to teach and, importantly, were not to teach. Teachers' adherence to the standards was fought for as the gauge of whether a teacher should be discredited, valorised or fired. Unions were dismantled in many places and teacher tenure dissolved in many more, all with the intention of binding teachers tightly to the standards. Pay for performance, or "merit pay" was also implemented in many districts to the same end.

The root of this movement dates to the 1980s and the Ronald Reagan administration. From his perspective of having been the Assistant Secretary for Education under Reagan, Chester

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Finn acknowledged that educators were sidelined and that business had a seat at the education policy table as never before. In "The Original Education President: Reagan'sABCs" for National Review he stressed, "the biggest symbol of that shift was 'A Nation at Risk,' the epochal 1983 report" which,of course, called for standards (Finn, Jr., C. E. 2004, p.1, June 9) . He proudly stated that "it was on Ronald Reagan's watch that 'the Sixties and Seventies' ended for American education, both literally and philosophically" (Ibid.). It was also Reagan that pulled out solar panels that his predecessor, Jimmy Carter, had installed on the White House and moved the country away from any discussion of departing from fossil fuels. The impact on current issues, such as environmental and climate sciences, is characterized by a hostile attitude towards research and experts in these fields, favoring lobbyists and contributing to a renewed culture war. The school standards that ensued, and nationally mandated by the George W. Bush administration in 2002, were, not surprisingly, aligned especially well with the goals of industry. The ideals of a liberal education, a Progressive education, and a democratic, critical or environmental education, were ridiculed and a concerted effort to tightly control teachers, students and school curricula took hold. Chester Finn, Diane Ravitch and other neo conservatives such as William Bennet and William Kristol, were beginning to see their long-fought efforts to strictly standardize school have a direct and major impact on American Education. That impact would result in control over information, avoiding the input of educators and removing educators that question or promote critical thought amongst their students. Very evidently, the rejection of educators' input and the neo-liberalizing of schooling was a conscious effort. And the power of legislatures to shape school curricula by way of politicians either motivated by blind ideological or monetary incentives is continually proving to be more powerful than the efforts of experts and educators. Indeed, over the past decades a disdain for experts and educators has dominated much of standards creation.

Though considered by himself and others to be quite the education expert, Chester Finn for many years has warned that education experts should not be heard. In 1997, in "Bad National Testing Program Worse than None" for Foresight, Hudson Institute Insights on Issues of the Day (1997), he berated a federal panel for having "only educators and experts" and not "a single 'consumer' or employer" among them (p. 2). Furthermore, he declared that "true reform demands distance from education experts" (ibid., p. 2). In the creation of educational standards, the latter stance prevailed. In 2003, Finn decried the National Standards for United States History as "drafted primarily by historians and history educators at UCLA" (Finn, 2003, p. 13). According to Finn the history standards these experts devised were "distortions" (ibid., p. 13) and he goes on to characterize "the faculty in our graduate schools of education" as "leftist ideologues" who promote "distortions and half-truths" about American history (ibid., p. 14). The following year, in 2004, Finn declared "whereas we once assumed that educators would do right by kids, now we know that their interests

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

often diverge and therefore insist on 'civilian control' of education and enhancing the role and leverage of parents. Power is shifting from producers to consumers and choices are proliferating in the education marketplace" (2004, p. 1).

3. The Impact on Environmental Education

The same sentiment towards experts in the sciences persists today. Writing for Scientific America, in 2022 Katie Worth recounted in "Subverting Climate Science in the Classroom" the Texas Board of Education's efforts to update the Texas Essential Knowledge and Skills (TEKS) for Science. According to Worth, it had last been updated some 13 years prior, in 2009, and chaired by a dentist from east-central Texas by the name of Don McLeroy. Worth writes "McLeroy made his views on science education clear when he declared at one meeting, 'Somebody's got to stand up to experts!' The board spent much of that adoption cycle clashing over evolution, but it also required that highschool environmental science students debate something scientists hadn't debated for a long time: whether global warming is happening. McLeroy told a reporter he was pleased because "'conservatives like me think the evidence is a bunch of hooey'" (Worth, 2022).

In October of 2023 in "Climate Misinformation Persists in New Middle School Textbooks" Worth reported that despite more meetings with educators and fossil fuel representatives over the science standards, progress was slow. Despite lawyers and lobbyists from the fossil fuel industry being a dominant force at the school board's science standards meeting, state congressman August Pflugger called the new, yet lacking introduction of climate science into the 8th grade curriculum, an example of "the radical lobby" trying to "infiltrate Texas middle schools" in an effort to "brainwash" the children (Worth, 2023).

From an environmental education perspective, the prospects of sufficient focus on climate change through standards is unlikely. At a national level we see the same aversion toward acknowledging or teaching about climate change abound. For example, during the ongoing campaign for a Republican presidential candidate many nominees disregarded and discredited climate change and the science that explains it. Ramaswamy called it a hoax (Harrison, 2023). Previous presidential candidate and current senator Marco Rubio referred to the EPA, the Environmental Protection Agency, as the Employment Prevention Agency (Reed 2016). The EPA, of course, is the federal agency charged with protecting the environment (water quality, identifying pesticides, classifying everyday toxins, emission standards and so on). Candidate Trump, along with Republican politicians more generally, continue to promise the removal of all environmental protections brought in under Biden.

And Trump made well on such promises before. From the perspective of environmental education and environmental policy, he proved to be less the populist he purported to be, the swamp drainer he said he would be in his cuff electoral theatre than a protector of vested

BY-NC-SA 2024, Editorial Universitat Politècnica de València

interests in acabinet staffed by billionaires and lobbyists. Upon taking office in 2017, Trump gave control of the EPA to one of its most virulent critics, Scott Pruitt, Attorney General from Oklahoma, who was perhaps best known for a slew of lawsuits to block environmental regulation in favour of polluting industries. As Director, Pruitt was committed to reducing the EPA's staff, eliminating key protective positions, and diminishing the EPA's regulatory capacity. He had even gone on national television to express doubt that carbon dioxide was a primary contributor to global warming. The agency's longtime scientists and engineers departed citing demoralization and "an administration that has openly accused the agency of producing junk science," such as the science of climate change.

Furthermore, Trump's choice for Secretary of State was Texan Rex Tillerson, the-time CEO of Exxon Mobil, the world's largest international oil and gas company. And with states like Texas—which is highly influential in how textbooks are produced for the nation as a whole—still weighing the wishes of fossil fuel companies to the degree that they help devise the schools' standards, it is clear that educators' and experts in climate science are still fighting an uphill battle to make climate change an important focus, let alone a requirement. So yes, this is a crisis, but the collusion of industry representatives on environmental advisory councils setting environmental and education standards is business as usual.

Limited progress, however, has been made. Finally in 2022 the Common Core State Standards (CCSS) included standards that focused on the science explaining climate change. And the Next Generation Science Standards (NGSS) have had them included since 2018. But the hopes that these standards will be taught is somewhat slim. To begin with, only 19 states have signed on to teach NGSS and with those, there is not necessarily a state mandate to teach all of the standards. The CCSS is also not as widely accepted as it was and, again, the various state standards that are mandated do not necessarily align well with the CCSS even in those states that have adopted them. Furthering the uphill battle to have the environment and climate change taught in schools is the ongoing political resistance to accepting that the environment is in need of protection and the climate is being affected by industrialism.

4. Solutions

Although teachers are not necessarily experts in climates science, science teachers in particular are aware of the importance of acting on climate change and other environmental issues. They are educated to both well understand the science behind the issues and are capable of continuing to learn from experts on such issues. In keeping with a majority of Americans, teachers also overwhelmingly believe that climate change and environmental education are of extreme importance. Allowing the special interests of the Super Constituency to dictate education policy is not only anti-democratic, but ignorant and perilous. Such anti-democratic governance must be countered in part by teachers and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

teacher unions. Teachers represent the citizenry far more accurately than do legislatures, and have no vested interest in teaching distortions or avoiding important subjects and issues. As with many other issues facing school, the refusal of teachers to contribute to environmental catastrophe by way of avoidance is vital. The destruction of unions across the United States was designed specifically to weaken the collective voice of the teacher; to weaken democracy. Perhaps ironically, it was Ronald Reagan who said "where free unions and collective bargaining are forbidden, freedom is lost" (Labor Day Address, 1980). Many around the world would say democracy is lost as well. In the United States both the loss of democratic representation and the loss of freedom for teachers and school districts to teach students about such issues as climate change is an unfortunate reality. To remedy both the lack of education on climate and environmental science, and restore the democratic governance of schools in the United States, we must push for the normalizing of teacher unions and teachers' voices being an integral part of the education policy making process.

Waiting for policies guided by the Super Constituency to emerge fromthe legislatures before calling them into question is a disservice to the school, the children in school, and education as a concept. This approach has resulted in the irrational, anti-educative, anti-democratic policies that have led to the strikes and walk outs seen in recent years. While such teacher action becomes an essential reaction to such policies, they are also a last resort and could be avoided. Professional organizations and unions, representing teachers, researchers and education scholars, are necessary elements in a path to education policy that is built on knowledge of teaching and learning and school's role in a democratic society. They are essential to policy that results from serious research which is both informed by, and informs, theory and practice. Without taking back control over education policy, the schools, the students, the democracy, along with the environment and global climate will continue to suffer the ill effects of policies designed by and for the Super Constituency.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Eileperin,J., Dennis, B., & Muyskens,J. (2020, October 30). *Trump rolled back more than 125 environmental safeguards. here'show.* Climaterand Environment.

https://www.washingtonpost.com/graphics/2020/climate-environment/trump-climate-environment-protections/

Finn, Jr., C E. (1997, September). Bad National Testing Program Worse than None. Foresight, Hudson institute insights on issues of the day. 1, (9) 1-4.

Finn, Jr., C. E. (2004, June 9). The Original Education President: Reagan'sABCs. National Review.

Harrison, D. (2023, December 11). *Vivek Ramaswamy called "The climate change agenda" a hoax in Alabama'sfirst-ever presidential debate. what did University of Alabama students think?* Inside Climate News. https://insideclimatenews.org/news/11122023/vivek - ramaswamy-climate-change-agenda-hoax-university-of-alabama-students/

Madelone, J. (2023, May 30). *The evolving landscape of climate change education*. Waterfront Alliance. https://waterfrontalliance.org/2023/05/25/the-evolving-landscape-of-climate-

change-education/

Mulcahy, D. E. (forthcoming) The super constituency and its influence in education policy," in *Philosophy, Theory, and Foundations in Education.* South Atlantic Philosophy of Education Society: Appalachian State University.

Popovich, N., Albeck-ripka, L., & Pierre-louis, K. (2020, October 16). *The Trump*

administration rolled back more than 100 environmental rules. here's thefull list. The New York Times. https://www.nytimes.com/interactive/2020/climate/trump-environment-

rollbacks-list.html

Reagan, R. (1980). Labor Day Address.

Reed, B. (2016, February 26). *Republican candidates' calls to scrap EPA met with skepticism by experts*. The Guardian.

https://www.theguardian.com/environment/2016/feb/26/republican-candidates-donald-trump-eliminate-epa-law-experts

Reed, B. (2024, January 18). *Climate crisis ignored by Republicans as Trump vows to "Drill, baby, Drill."* The Guardian. https://www.theguardian.com/us-news/2024/jan/18/trump-republican-rivals-climate-crisis

Worth, K. (2024a, February 20). *Climate misinformation persists in new middle school textbooks*. Scientific American. https://www.scientificamerican.com/article/climate - misinformation-persists-in-new-middle-school-textbooks/

Worth, K. (2024b, February 20). *Subverting climate science in the classroom*. Scientific American. https://www.scientificamerican.com/article/subverting-climate-science-in-the- classroom/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Semantic Prosody In The Field Of Environment And Climate Change: A Corpus-Based Analysis

Katrin Herget[a] and Teresa Alegre[b]

[a]Department of Languages and Cultures/CLLC, University of Aveiro, Portugal
[b]Department of Languages and Cultures/CLLC, University of Aveiro, Portugal

Abstract

The present study focuses on the analysis of semantic prosody in the field of environment and climate change policies. Due to a growing social awareness of climate change and the importance of addressing this highly complex topic, there is an increasing demand for climate change education, showing its implications to the general public. Several international organizations are engaged in enlightening the community on this topic. The fact that climate change affects the entire world population, contributes to the importance of giving the society access to clear and simple information and consequently the necessary know-how in this field. This study aims at contributing to the exploration and analysis of semantic prosody of the lexical items de. *Fracking* and pt. *fracking* by co-occurrence analysis in two large-scale corpora. In terms of methodology, we conducted an exploratory qualitative and quantitative study, based on the analysis of two comparable web-crawled corpora, available in the concordance tool Sketch Engine: German Web 2020 (deTenTen20) and Portuguese Web 2020 (ptTenTen20). The corpus analysis revealed, in both languages, a negative semantic prosody associated with the terms de. *Fracking* and pt. *fracking*, being visible in controversial debates in German society, as well as in Portuguese and Brazilian news texts.

Keywords: semantic prosody; corpus analysis; environment and climate change policies; SketchEngine; German-Portuguese.

How to cite: Herget, K. and Alegre, T. (2024) Semantic prosody in the field of environment and climate change: a corpus-based analysis. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 679-688. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The present research centers on analysing semantic prosody within the context of environment and climate change policies. With the increasing societal awareness of climate change, there is a growing demand for climate change education to elucidate its implications for the broader public. Notably, various international organisations, such as the United Nations and the World Meteorological Organization, are actively involved in disseminating information on this pressing issue. Given the global impact of climate change, providing accessible and clear information to society is crucial to provide individuals with the necessary knowledge in this field. This study on semantic prosody aims to raise awareness in environmental discourse by examining terms that have gained prominence in media texts. Specifically, the analysis focuses on *fracking*, an extraction technique of gas and oil from deep underground, which has prompted environmental concerns. The geopolitical implications of energy sources and supply have amplified the visibility of this extraction method in the media. To our research purpose, we delimited the corpus analysis to the search words de. *Fracking* and pt. *fracking*. Due to geopolitical implications of energy sources and energy supply, this extraction method has gained more visibility in the media.

2. Environment and climate change policies – from scientific to public discourse

The increase in the number of publications of popular science texts has contributed to a very remarkable popularization of environmental science. Apart from the official information disseminated by world organizations such as Intergovernmental Panel on Climate Change (IPCC)[1] or the World Meteorological Organization, as well as by science popularization journals, these issues also emerge in the general press in a large variety of news texts sections (interviews, news reports, articles, stories, opinion articles, and so on). News texts potentially contribute to educate and influence the general reader, as they provide local and global information on subjects relevant for our everyday lives. In line with Calsamiglia & van Dijk (2004), in this study we understand popularization in broader terms as a vast class of various types of communicative events or genres that involve the transformation of specialized knowledge into "everyday" or "lay" knowledge, as well as recontextualization of scientific discourse, for instance, in the realms of the public discourse of the mass media or other institutions (Calsamiglia & van Dijk, 2004, pp. 370-371).

[1] "Due to the global significance of climate change and its complex scientific implications the World Meteorological Association (WMO) and the United Nations Environment Programme (UNEP) founded the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC is an independent scientific body whose memberships consists of hundreds of scientists from all over the globe. It reviews and assesses the most recent scientific information produced worldwide relevant to the understanding of climate change" (https://www.umweltbundesamt.de/en/topics/climate-energy/climate-change/intergovernmental-panel-on-climate-change-ipcc).

2024, Editorial Universitat Politècnica de València BY-NC-SA

This dissemination of relevant topics contributes to the familiarization of a broader audience with specific domains and consequently with specialized vocabulary. As a consequence, the lay public becomes more enlightened. Over the last decades, we have witnessed a growing interest of the general public towards scientific topics. The presence of science in our daily lives can be seen in every communication channel, ranging from print media, over broadcast to digital media (social media, websites, apps, among others).

In general terms, science popularisation has been widely studied in the context of Languages for Specific Purposes (LSP), which can be structured vertically, according to the communication complexity, which shows different degrees of specificity (or technicality, in German *Fachlichkeitsgrad*), as well as different levels of abstraction, textual genres and discourse participants.

Our analysis is based on previously created typologies (Löning, 1981; Hoffmann, 1985; Arntz, 2001), which we adapted to our needs, paying special attention to the analysis of general news texts. Against the backdrop of exploring semantic prosody, with regard to the field of environmental and climate change policies, five different communicative situations can be identified, involving various discourse participants, aims, text types, textual genres and channels.

1.1 discourse participants: scientist / environmental expert - scientist / environmental expert (within the same domain)
1.2 aim: intra-domain transfer of current scientific knowledge
1.3 text type: informative
1.4 textual genres: scientific articles, reports
1.5 channel: print, digital

2.1 discourse participants: scientist / environmental expert - scientist / environmental expert (from different domains)
2.2 aim: inter-domain transfer of current scientific knowledge
2.3 text type: informative
2.4 textual genres: scientific articles, reports
2.5 channel: print, digital

3.1 discourse participants: professional - semi-professional (working groups, technical support units - policymakers: politicians, scientific advisers, civil servants)
3.2 aim: transfer of essential knowledge
3.3 style: informative and operative
3.4 textual genres: reports, summary reports
3.5 channel: print, digital, broadcast

4.1 discourse participants: professional - lay public (specialized/technical journalists - reader)
4.2 aim: dissemination of scientific knowledge, awareness raising
4.3 style: informative, operative, expressive
4.4 textual genres: popular science journal article, monographs, information leaflets, ...

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4.5 channel: print, digital, broadcast

5.1 discourse participants: general media journalist - lay public (journalist - reader)
5.2 aim: dissemination of basic scientific knowledge, awareness raising
5.3 style: informative, operative, expressive
5.4 textual genres: articles in newspapers and magazines of general interest
5.5 channel: print, digital, broadcast

Considering that both TenTen corpora are web-crawled texts, our focus will be on the communicative situations of levels 3 to 5, which involves semi-professional and lay public as target groups.

3. Semantic prosody

Across the relevant literature, the term 'semantic prosody' encompasses a wide range of interpretations and characteristics (Stewart, 2010). The term itself was coined by Louw in 1993, representing a "consistent aura of meaning with which a form is imbued by its collocates" (1993, p. 157). With regard to the concept, Sinclair (1991, p. 112) had already observed that "[m]any uses of words and phrases show a tendency to occur in a certain semantic environment. For example, the verb *happen* is associated with unpleasant things – accidents and the like'". In later publications, the author defines semantic prosody as "attitudinal and on the pragmatic side of the semantics-pragmatics continuum" (Sinclair, 1996, 87). Xiao & McEnery (2006, pp. 105-106) provide a concise summary on the main authors, who conducted research in the field of semantic prosody, mentioning Sinclair (1991), Louw (1993), Stubbs (1995, 1996), Partington (1998), Hunston (2007), among others. Without delving into the issue of delimitation, in the following study, within the context of environment and climate change policies, we perceive semantic prosody as an evaluative association (positive or negative) that an apparent denotatively neutral lexical unit can acquire when co-occurring with other words in a given context (Alcaraz-Mármol & Soto Almela, 2015, p. 146).

4. Methodology

In terms of methodology, we conducted an exploratory qualitative and quantitative study, based on the analysis of two text corpora, deTenTen and ptTenTen, retrieved from SketchEngine. Both corpora contain text collections from the year 2020 and cover "the largest possible variety of genres, topics, text types and web sources" (Sketch Engine, 2023). The text collections belong to the TenTen corpus family, i.e. "a set of web corpora built using the same method with a target size 10+ billion words" (Sketch Engine, 2023). The importance of comparable corpora in the field of Language Technology is assuming an increasing significance for the extraction of terminological and phraseological units, also providing a better understanding of different language registers and varieties. Krüger (2012, pp. 507-508)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

emphasises the fact that corpora "allow for a better contextualisation and control of the texts to be investigated and provide a higher representativeness [sic], generalisability [sic] and replicability of the findings". The data analysis was carried out with the concordance tool SketchEngine, with the aim of collecting co-occurrences of the search words de. *Fracking* and pt. *fracking.*

5. Corpus Analysis

To quantify and exemplify instances of semantic prosody in the field of environment and climate change policies, we analysed the lexical units de. *Fracking*, pt. *fracking*, due to their relevance in the current environmental discussion. Lexical variants pt. *fraturação*, pt. *fraturamento hidráulico* were not contemplated to facilitate a more accurate comparison of the English loanword in both languages. The following table (1) shows the frequency of occurrences of the search word in each corpus.

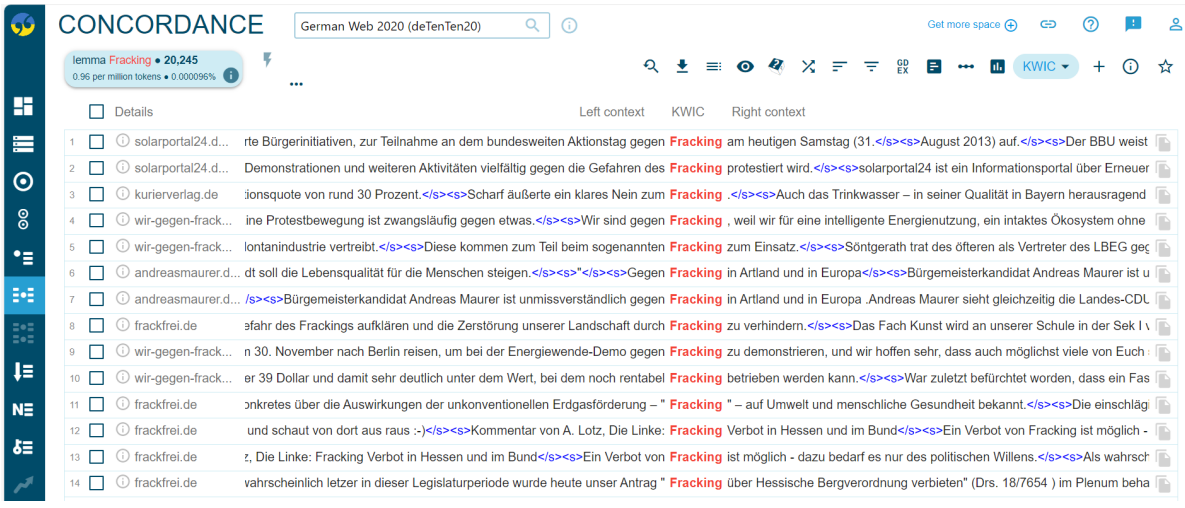
Table 1 – Corpus info and number of occurrences of search word *Fracking/fracking*

Lexical unit (German)	Total number of tokens (deTenTen)	Occurrences of *Fracking*	Lexical unit (Portuguese)	Total number of tokens (ptTenTen)	Occurrences of *fracking*
Fracking	20,999,598,683	20,245	*fracking*	14,888,656,035	2,608

Source: Own elaboration

In terms of analysis, we searched the de.TenTen corpus for instances of the lemma *Fracking* as a noun and obtained 20,245 instances.

Fig. 1 – Concordance results of de. *Fracking*



Source: Sketch Engine (2023)

The search in the Portuguese corpus revealed a much lesser number of occurrences, a total of 2,608. A possible explanation for the difference in quantity, may be related to the existence

BY-NC-SA 2024, Editorial Universitat Politècnica de València

of three competitive lexical variants (pt. *fracking*, pt. *fraturamento*, pt. *fraturação*) in the Portuguese language.

Fig. 2 – Concordance results of pt. *proibição* + *fracking*



Source: Sketch Engine (2023)

In a next step, we analysed the co-occurrences that appear together with the node word. After applying a stop word list for the exclusion of such words that may lead to noise and inefficiencies, the most frequent denotatively neutral collocates in the German corpus, within a span from -3L to 3R, were as follows: *Thema* (725), *Deutschland* (601), *USA* (434), *Gas* (288), *Erdgas* (235), *Einsatz* (182), *sogenannte/n* (280), *Schiefergas* (162), *Förderung* (150), *Gasförderung* (127), *Fracturing* (126), *Methode* (120), *Erdgasförderung* (118), *Europa* (69), Kohle (87), *Verfahren* (84), *Fördermethode* (70), *Erdgasgewinnung* (70), *Gesetz* (68), *Technologie* (68).

From the Portuguese corpus, the following denotatively neutral lexical units were extracted: *Brasil* (186), *hidráulico/a* (252), *fraturamento* (134), *técnica* (78), *gás* (64), *método* (60), *conhecido/a* (81), *xisto* (51), *petróleo* (51), *tecnologia* (49), *indústria* (49), *processo* (45), *exploração* (40), *extração* (35) *EUA* (33), *perfuração* (24), *produção* (20), *chamado* (20), *fractura* (11), *fra(c)turação* (19).

This table shows the number of negative co-occurrences of the respective search word in each language corpus.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Table 2 – Negative co-occurrences with lemmas de. *Fracking* and pt. *fracking* (span 3L-3R)

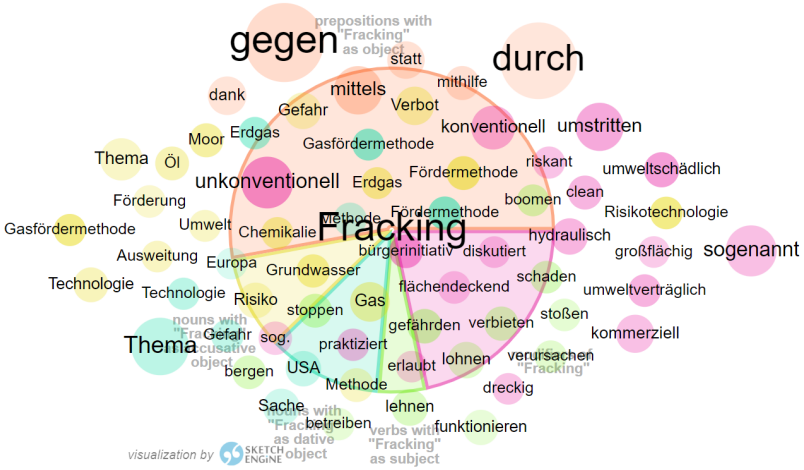
German	Portuguese
Co-occurrences (1L)	**Co-occurrences (1L)**
gegen (1055), unkonventionell (256), umstrittenen (179), teuer (24), gefährlich (22), Stopp (10), dreckig (8), riskant (8), umwelttoxisch (6), kostspielig (6), umweltzerstörend (5), schädlich (5), klimaschädlich (5), giftig (4)	Não (153), anti (11), proíbe/proibir (4), STOP (3), risco/s (2), poluente (1), terremotos (1), opõem (1)
Co-occurrences (2L)	**Co-occurrences (2L)**
Verbot (305), umstritten (88), Widerstand (50), Risiko (49), Umweltauswirkung (49), Gefahr (41), Protest (34), Ablehnung (31), Kampf (29), Kritik (17), Verhinderung (13), Umweltschaden (13), Umweltrisiko (9), Problem (8), Stopp (7)	Coalizão/Coalização (102), contra (53), proibir/proíbe/proibiram/proibiu (25), NÃO/Não (22), proibição (16), P/perigos (14), impacto/s (8), riscos (8), banir (5), combate (4), ameaça (4), ativistas (4), parar (3), Guerra (3), opõem (3), inconvenientes (3), restrições (3), poluente (1)
Co-occurrences (3L)	**Co-occurrences (3L)**
unkonventionell (54), gegen (51), Verbot (30), umstritten (21), kritisch (11), s. wehren (7), negativ (7), ablehnen (7), umweltschädlich (7)	não (21), contra (14), luta (9), proibição (6), impedir (5), terremotos (4), ameaça (4), problemas (4), proíbe/proibiu (4), poluente (3), riscos (3), perigosos (2), contaminação (2)
Co-occurrences (1R)	**Co-occurrences (1R)**
verbieten (45), verzichten (auf) (15), ablehnen (13), verursacht (9), stoppen (9), s. wehren (8), verursachen (8), zerstören (7), gefährden (7), demonstrieren (6), Verbot (6), protestieren (6)	afeta (3), ameça (1), proibido (1), contaminando (1)
Co-occurrences (2R)	**Co-occurrences (2R)**
verbieten (41), unkonventionell (32), gegen (26), verhindern (14), giftig (13), Gefahr (11), Risiko (10), Verbot (8), Gift (6)	proibido/proibir (7), terremotos (4), contaminar/contaminando (4), ameaça (1), poluente (1), risco (1)
Co-occurrences (3R)	**Co-occurrences (3R)**
verbieten (32), umstritten (21), unkonventionell (21), Gefahr (15), Problem (9), verhindern (9), giftig (6)	contaminação (3), riscos (3), impacto (3), contra (3), proibir/proibido (2), contaminando (1), terremotos (1)

Source: Own elaboration

The lexical environment of the search word de. *Fracking* is represented in the following visualization (Fig. 3), giving an overview of the most frequent co-occurrences.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

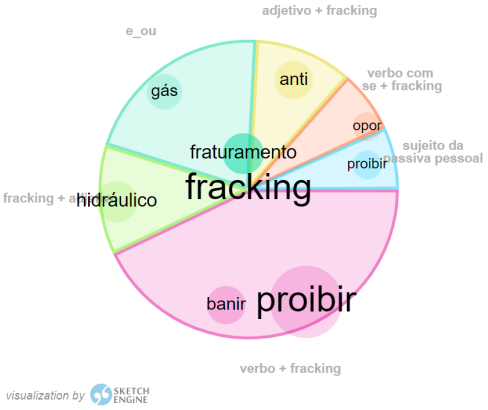
Fig. 3 – Lexical environment of the node de. *Fracking*



Source: Sketch Engine - Word Sketch (2023)

Reflecting the lexical setting of the Portuguese corpus, Fig. 4 illustrates the co-occurrences of the Portuguese search word *fracking*.

Fig. 4 – Lexical environment of the node word pt. *fracking*



Source: Sketch Engine - Word Sketch (2023)

6. Results and discussion

The study of semantic prosody in the field of environment and climate change policies aimed at contributing to the exploration of large-scale comparable corpora in German and Portuguese. The linguistic analysis of the search words de. *Fracking* and pt. *fracking* contributed to identify the semantic associations with this extraction method. The corpus analysis underlined the negative views towards both lexical units, highlighting the concerns about its environmental impact and its associated risks. By searching co-occurrences within the span of 3L to 3R, a total number of 66 negative words, such as *gegen*, *Verbot*, *unkonventionell*, *umstritten*, *Widerstand*, *gefährlich*, *dreckig*, *umwelttoxisch*, *kostspielig*, *umweltzerstörend*, and *schädlich* were extracted from the German corpus. In comparison to the German corpus, the results of the Portuguese corpus were not so striking. A total of 27

BY-NC-SA

negative words, such as *não*, *proibir*, *proibição*, *contra*, *perigos*, *terremotos*, *contaminação*, and *poluente*, associated with pt. *fracking* were identified in the Portuguese corpus. The reasons for this discrepancy may be related to the previously mentioned lexical variation of pt. *fracking*, but also to a less significant debate about this extraction method and its environmental consequences in Portuguese and Brazilian media. However, evidence of social movements (e.g. COESUS – Coalizão Não Fracking Brasil e pela Sustentabilidade) addressing the environmental dangers can be found in the Portuguese corpus.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Alcaraz-Mármol, G. & Soto Almela, J. (2015). The semantic prosody of the words inmigración and inmigrante in the Spanish written media: A corpus-based study of two national newspapers. *Revista Signos. Estudios de Lingüística*, 145-167.

Arntz, R. (2001). *Fachbezogene Mehrsprachigkeit in Recht und Technik*. Olms.

Calsamiglia H. & Van Dijk, T. A. (2004). Popularization discourse and knowledge about the genome. *Discourse and Society*, 15(4), 369-389.

Hoffmann, L. (1985). *Kommunikationsmittel Fachsprache. Eine Einführung* (2. völlig neu überarbeitete Auflage). Narr.

Hunston, S. (2007). Semantic prosody revisited. *International Journal of Corpus Linguistics*, 12(2), 249-268. http://dx.doi.org/10.1075/ijcl.12.2

Kübler, N., & Volanschi, A. (2012). Semantic prosody and specialised translation, or how a lexico-grammatical theory of language can help with specialized translation. In A. Boulton, S. Carter Thomas, & E. Rowley-Jolivet. *Corpus-informed Research and Learning in ESP: Issues and Applications*, John Benjamins Publishing Company, pp.105-135.

McEnery, T. & Hardie, A. (2012). *Corpus Linguistics: Method, Theory and Practice.* Cambridge: Cambridge University Press.

Löning, P. (1981). Zur medizinischen Fachsprache. Stilistische Gliederung und Textanalysen. *Muttersprache* 91, 79-92.

Louw, B. 1993. Irony in the text or insincerity in the writer? The Diagnostic Potential of Semantic Prosodies. In M. Baker et al. (eds). *Text and Technology*. In Honour of John Sinclair. (pp. 157-176). Benjamins.

Partington, A. (1998). Patterns and Meanings – Using Corpora for English Language Research and Teaching. Amsterdam/Philadelphia: John Benjamins.

Sinclair, J. (1991). *Corpus, concordance, collocation*. Oxford, England: Oxford University Press.

Sinclair, J. (1996). The Search for Units of Meaning. *Textus* IX. 75-106.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Stewart, D. (2010). *Semantic Prosody.* Routledge.

Stubbs, M. (1995). Collocations and semantic profiles: On the cause of the trouble with quantitative methods. *Function of Language*, (2)1, 1–33.

Xiao, Z. & McEnery, A. (2006). Collocation, Semantic Prosody, and Near Synonymy-A Cross-Linguistic Perspective. *Applied Linguistics*, 27:1, 103-129.

2024, Editorial Universitat Politècnica de València BY-NC-SA

OneClickQuiz: Instant GEN AI-Driven Quiz Generation in Moodle

Antoun Yaacoub[a], Siba Haidar[a] and Jérôme Da Rugna[a]

[a]LDR, ESIEALab, ESIEA, Paris, France

Abstract

This paper presents an innovative strategy for the generation of quizzes and multiple-choice questions (MCQs) within Moodle, leveraging the advanced capabilities of Generative AI through Google's PALM2 models. This approach not only revolutionizes educational workflows but also aligns with the principles of sustainable education by fostering a more adaptive, personalized, and resource-efficient learning environment. Designed to substantially streamline educational workflows, our novel Moodle plugin directly addresses the challenges of extensive quiz preparation faced by educators and the necessity for engaging, tailored learning experiences for students. Through rigorous evaluation with both educators and students, our research validates the plugin's efficiency in diminishing administrative tasks and enhancing academic engagement and performance. Key outcomes highlight the plugin's user-friendliness, educational value, and pioneering influence on content generation, leading to a more dynamic and interactive educational environment. This study not only underscores the transformative potential of integrating cutting-edge AI technologies into educational platforms but also lays the groundwork for future investigations into the broad applications of AI in enriching teaching and learning experiences. The broader implications of our findings suggest a vibrant future for digital education, characterized by adaptive, personalized, and enriched learning ecosystems.

Keywords: Generative AI; Automated Quiz Generation; Educational Technology; Teaching and learning experiences; Emerging technologies in learning.

How to cite: Yaacoub, A.; Haidara, S. and Da Rugna, J. (2024) OneClickQuiz: Instant GEN AI-Driven Quiz Generation in Moodle. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 689-698. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the dynamic domain of digital education, the integration of Artificial Intelligence (AI) technologies plays a pivotal role in revolutionizing learning experiences and streamlining administrative processes. Importantly, the integration of these technologies embodies the essence of sustainable education by promoting efficiency, reducing resource consumption, and preparing students with the competencies needed for a sustainable future. Amidst this transformation, the creation of quizzes and other evaluative tools emerges as a critical yet time-intensive task for educators, essential for gauging student learning outcomes. The advent of AI in educational assessment promises significant advancements, offering avenues for enhanced educational quality and operational efficiency. However, the landscape of existing AI-based quiz systems, despite their diversity, often faces limitations in adaptability, content generation, and the ability to cater to diverse learning styles and proficiency levels. These shortcomings highlight a pressing need for employing more sophisticated AI models that can not only automate the generation of quizzes but also ensure the quality and relevance of content. This study aims to address these challenges by developing and evaluating a Moodle plugin that leverages advanced Generative AI—specifically Google's text-bison model—to automate and enrich the quiz creation process, thereby reducing the workload on educators and enhancing the learning content's dynamism and contextual richness.

2. Literature Review

This literature review explores three essential dimensions in the current discourse on AI in education. Initially, it investigates recent advancements in Generative AI for educational applications. Subsequently, it studies documented limitations within existing AI-based educational tools. Lastly, the review examines the role of AI in shaping assessment methods and curriculum development within the educational landscape.

2.1 Advances in Generative AI for Education

Large Language Models (LLMs) like GPT-4, and PALM2 are significantly influencing educational paradigms. Studies by (Eager & Brunton, 2023), (Trust et al., 2023), and others illustrate LLMs' capabilities in augmenting teaching practices, assessment design, and curriculum development. Integrating further insights, (Pack & Maloney, 2023) demonstrates how OpenAI's ChatGPT can be a valuable tool for language education researchers, exemplifying its applications in information compilation, summarization, and research assistance. Additionally, (Zhai & Nehm, 2023) argues for the extensive and diverse use of AI in formative assessment, challenging restrictive views and emphasizing its potential benefits in providing feedback, aiding teachers, and diversifying assessment modalities.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Generative AI has profoundly impacted education, as seen in the work of (Olga et al., 2023), who explore its diverse applications in enhancing and personalizing learning experiences. (Doughty et al., 2024) demonstrate GPT-4's effectiveness in generating programming MCQs, showcasing AI's potential in creating high-quality, relevant educational content. (Van Campenhout et al., 2022) extend this by evaluating AI-generated questions in Psychology, using student data and perceptions for a comprehensive assessment. (Eager & Brunton, 2023) discuss AI's role in augmenting teaching and learning practices, while (Trust et al., 2023) focus on ChatGPT's implications in teacher education, highlighting its rapid growth and transformative impact. These advancements in LLMs demonstrate the potential for creating more engaging and contextually relevant educational content, a key component of our proposed quiz generation tool.

2.2 Limitations in Current AI-based Educational Tools

The ethical and societal challenges of AI in education are highlighted by (Akgun & Greenhow, 2022), who emphasize the need for awareness and education about AI ethics in K-12 settings. (Dai & Ke, 2022)'s review on AI in simulation-based learning indicates the need for careful integration of AI with learning principles. Concerns about bias, transparency, and equity in AI tools are also noted, underscoring the need for responsible AI implementation (Bahroun et al., 2023). These ethical challenges highlight the need for careful consideration in the deployment of AI-based educational tools, ensuring they are designed with fairness and transparency at their core.

2.3 AI in Assessment and Curriculum Development

(Grévisse, 2024) evaluates the quality of GPT-based MCQs, focusing on the alignment with best practices for MCQ creation. (Jain, 2015)'s work on automated quiz generation in programming languages highlights the potential of AI in creating educational assessments and materials. This review underscores the potential for AI to significantly enhance assessment methods, laying the groundwork for our development of an AI-enhanced Moodle plugin aimed at automating quiz generation.

In line with the acquired insights, the subsequent methodology section outlines a framework for the development and deployment of our Moodle plugin. This section delineates the phases, starting from the plugin's conceptualization to the assimilation of user feedback. This approach ensures a precise examination of AI's multifaceted role in education, emphasizing the pragmatic realization of its transformative capabilities within the bounds of responsible implementation, contributing to a comprehensive and trustworthy educational technology solution.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Methodology

This section outlines the development process and deployment strategy of our innovative Moodle plugin, designed to automate the generation of quizzes and multiple-choice questions (MCQs) using Generative AI. By leveraging Google's text-bison generative AI model, the plugin aims to significantly reduce the time educators spend on quiz preparation, thereby enhancing the efficiency of teaching and learning experiences.

3.1 Development of the Moodle Plugin

The development phase involved the creation of a user-friendly interface that allows educators and students to specify their subject matter and select the desired difficulty level for the quizzes. Utilizing these inputs, the plugin generates tailored API requests to text-bison model, which in return produces content-specific questions.

3.2 Integration with PALM2 API

A key aspect of our methodology was the integration of the Moodle plugin with the PALM2 API. This integration was achieved through PHP scripting, enabling seamless communication between the plugin and the API. This setup ensures the automated generation of educational content, aligning with our goals of innovation and functionality.

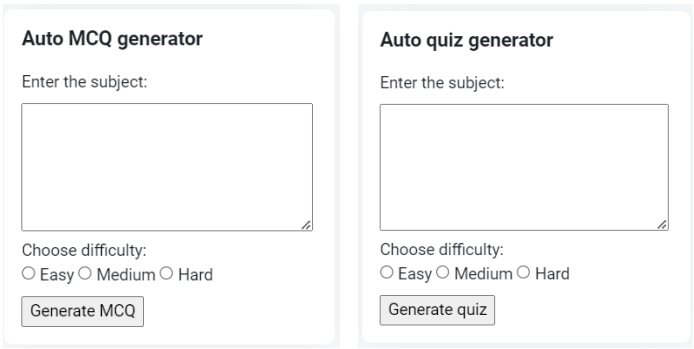
3.3 Educator Plugin Functionality

Educators can utilize the plugin (Fig.1) to generate new questions in JSON format with a single API request. These questions are then added to a question bank, where they can be reviewed, edited, approved, and categorized by educators based on difficulty level and content relevance.

3.4 Student Plugin Functionality

From the students' perspective, the plugin (Fig.1) offers the capability to generate five unique questions based on the chosen difficulty level (Fig.2).

Fig. 1 – Plugin interface. On the left educators' plugin, on the right students' plugin



Source: Own elaboration

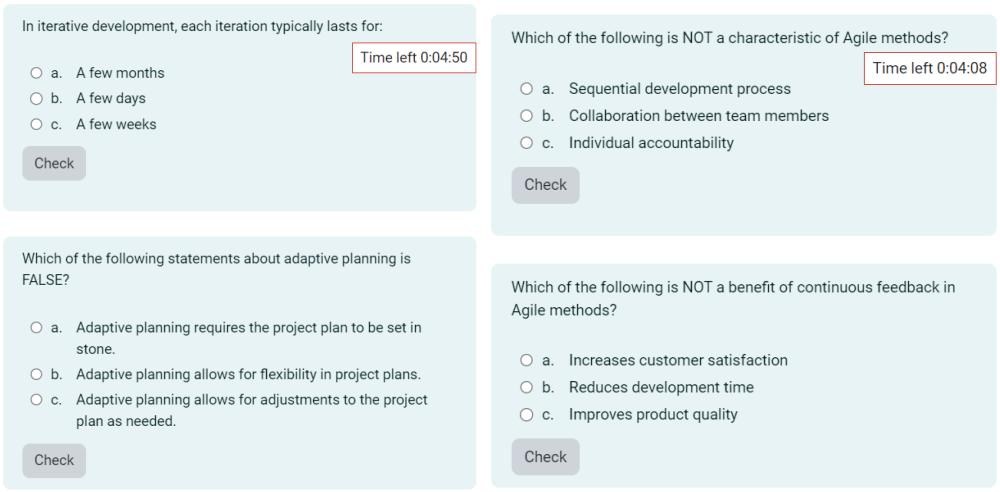
BY-NC-SA

These questions, received in JSON format, are automatically categorized and compiled into personalized quizzes. Students are invited to attempt these quizzes, providing them with a customized learning experience.

3.5 User Feedback Incorporation Strategy

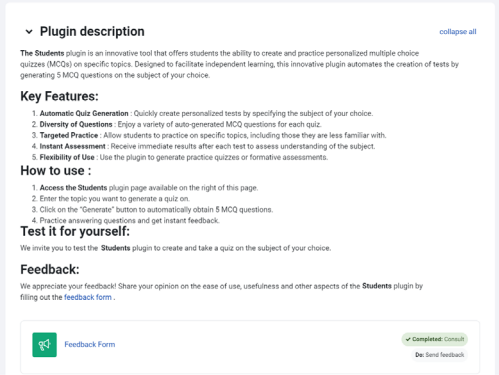
An essential component of our methodology was the collection and incorporation of user feedback. A dedicated page (Fig.3) on Moodle was created to inform users about the plugin, allow them to generate quizzes, and view the outcomes. After interacting with the plugin, users were prompted to complete a feedback form consisting of three closed and four open-ended questions, addressing aspects such as ease of use, educational value, originality, and areas for improvement. This feedback is crucial for the ongoing enhancement of the plugin, ensuring it effectively meets the needs of its users.

Fig. 2 Part of a generated quiz (4 questions out of 5) about "agile method" level "easy"



Source: Own elaboration

Fig. 3 – Plugin description page for students



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.6 Transparent Use and Payment Structure

The plugin's design ensures transparent use for educators and students, with the underlying API requests being financially covered by the institution. This arrangement is crucial to guarantee equal access to the plugin's features, irrespective of individual financial constraints. By handling the payment issues at the institutional level, the plugin remains accessible and equitable for all users, fostering an inclusive educational environment where access to advanced AI-generated educational tools is not limited by personal financial circumstances.

The plugin's design emphasizes transparent usage and an equitable access model. The costs associated with API requests are covered by the institution, ensuring that all educators and students can benefit from the plugin regardless of personal financial circumstances. This approach promotes inclusivity and equitable access to advanced educational technologies.

In the following section, we present a comprehensive analysis of feedback received from both educators and students on the AI-enhanced quiz plugin.

4. Results and Discussion

This section presents the outcomes of our comprehensive evaluation of the AI-enhanced quiz system, focusing on its impact on educators' preparation time, students' engagement, and the overall reception by both groups. A key component of our analysis focuses on sentiment, assessing the perceptions and attitudes towards the usability and effectiveness of the tool.

We gathered feedback from a diverse group comprising 15 educators and 30 students. This feedback was instrumental in assessing the system's usability, effectiveness, and impact on teaching and learning experiences. The analysis, supported by sentiment insights visualized in Fig. 4, presents the average sentiment by question and group, offering insight into the overall reception of the quiz system among our participants.

4.1 Educator and Student Feedback Analysis

Our analysis of educator feedback revealed a notable reduction in quiz preparation time, with educators reporting a significant decrease in the hours spent creating quizzes and MCQs. This efficiency gain underscores the plugin's effectiveness in streamlining administrative tasks, allowing educators to allocate more time to interactive and personalized teaching methods. The sentiment analysis indicated a positive reception, with educators highlighting the plugin's ease of use (Sentiment: 0.53), practicality, and educational utility (Sentiment: 0.87), alongside its originality (Sentiment: 0.87) and intended usage (Sentiment: 0.6). Suggestions for improvement were constructive, focusing on enhancing the user experience with mixed sentiment (Sentiment: Mixed - Positive and Constructive Feedback: 0.53).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Feedback from students emphasized the plugin's role in improving reactivity and engagement with course materials. Students appreciated the tailored difficulty levels and the variety of questions generated, which contributed to a more personalized and adaptive learning experience. Positive sentiments were expressed regarding the plugin's ease of use (Sentiment: 0.37), usefulness (Sentiment: 0.57), and originality (Sentiment: 0.57). Students also provided specific suggestions for customization options and export features, reflecting a mixed sentiment focused on enhancement (Sentiment: Mixed: 0.5).

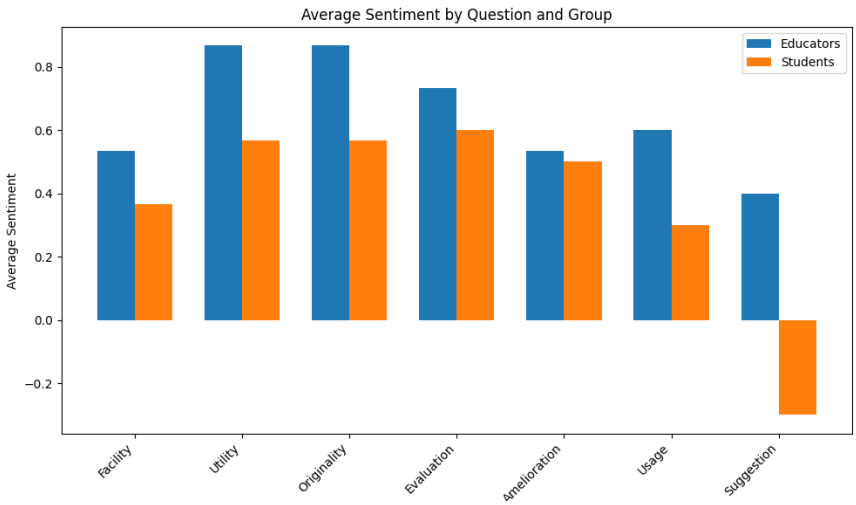
4.2 Interpretation of Results

The overwhelmingly positive feedback from both educators and students validates the AI-enhanced quiz system's role in transforming the educational process. For educators, the significant time savings in quiz preparation highlight the system's efficiency and its potential to contribute to more dynamic and interactive pedagogical strategies. For students, the improved reactivity and customization of the learning experience underscore the plugin's value in engaging and effective education.

4.3 Transformative Impacts of AI on Educational Efficiency and Engagement

The AI-enhanced quiz system significantly reduces quiz preparation time for educators and increases student engagement through personalized learning experiences. Its user-friendly interface and capacity to generate diverse, tailored content have been positively received, highlighting the system's effectiveness in streamlining teaching processes and enriching learning environments. This innovative use of AI in education not only demonstrates immediate benefits but also suggests a transformative potential for digital learning, advocating for broader applications of AI technologies to foster more efficient and engaging educational experiences.

Fig. 4 – Average Sentiment by Question and Group



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

5. Conclusion

This study has demonstrated the substantial benefits of leveraging Generative AI, specifically through the development of a Moodle plugin utilizing Google's text-bison generative AI model, to automate and enhance the creation of quizzes and MCQs. Our findings underline the potential of AI-enhanced tools in contributing to sustainable education practices, not only by optimizing resource use but also by empowering educators and learners in a constantly evolving digital landscape. By embracing these technologies, we take a step forward in building an education system that is sustainable, resilient, and adaptable to future challenges. The system significantly reduces preparation time for educators and increases engagement among students by providing personalized and adaptive learning experiences. Feedback from both educators and students has been overwhelmingly positive, emphasizing the system's ease of use, educational utility, and innovative approach to content generation.

The findings suggest that the AI-enhanced quiz system not only streamlines educational administrative tasks but also enriches the teaching and learning environment. This aligns with our objective to facilitate more efficient educational practices and underscores the transformative potential of AI in education. Based on the encouraging results and feedback, future research should explore expanding the plugin's capabilities, including the generation of more complex question types akin to those evaluated by (Haidar et al., 2023) in their study on a new programming teaching methodology using CodeRunner. The integration of personalized feedback mechanisms should also be a focus of continued development. Additionally, further investigation into the applicability of the plugin across various educational contexts and disciplines would be beneficial. Recognizing the potential impact on the wider educational community, we are committed to releasing this plugin as an open-source tool for Moodle.

Acknowledgements

We extend our sincere thanks to our institution for the funding that made this research possible. We thank our institution for its support and ESIEA for fostering an innovative research environment. Special thanks to our former colleagues for their invaluable insights and contributions to our work.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education : Addressing ethical challenges in K-12 settings. AI and Ethics, 2(3), 431-440. https://doi.org/10.1007/s43681-021-00096-7

Bahroun, Z., Anane, C., Ahmed, V., & Zacca, A. (2023). Transforming Education : A Comprehensive Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis. Sustainability, 15(17), Art. 17. https://doi.org/10.3390/su151712983

Dai, C.-P., & Ke, F. (2022). Educational applications of artificial intelligence in simulation-based learning : A systematic mapping review. Computers and Education: Artificial Intelligence, 3, 100087. https://doi.org/10.1016/j.caeai.2022.100087

Doughty, J., Wan, Z., Bompelli, A., Qayum, J., Wang, T., Zhang, J., Zheng, Y., Doyle, A., Sridhar, P., Agarwal, A., Bogart, C., Keylor, E., Kultur, C., Savelka, J., & Sakr, M. (2024). A Comparative Study of AI-Generated (GPT-4) and Human-crafted MCQs in Programming Education. Proceedings of the 26th Australasian Computing Education Conference, 114-123. https://doi.org/10.1145/3636243.3636256

Eager, B., & Brunton, R. (2023). Prompting Higher Education Towards AI-Augmented Teaching and Learning Practice. Journal of University Teaching & Learning Practice, 20(5). https://doi.org/10.53761/1.20.5.02

Grévisse, C. (2024). Comparative Quality Analysis of GPT-Based Multiple Choice Question Generation. In H. Florez & M. Leon (Éds.), Applied Informatics (p. 435-447). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-46813-1_29

Haidar, S., Yaacoub, A., & Ionascu, F. (2023). Evaluating the Effectiveness of a New Programming Teaching Methodology Using CodeRunner. In D. Guralnick, M. E. Auer, & A. Poce (Éds.), Creative Approaches to Technology-Enhanced Learning for the Workplace and Higher Education (p. 211-223). Springer Nature Switzerland.

Jain, S. (2015). Automated generation of programming language quizzes. Proceedings of the 2015 10th Joint Meeting on Foundations of Software Engineering, 1051-1053. https://doi.org/10.1145/2786805.2807559

Olga, A., Tzirides, Saini, A., Zapata, G., Searsmith, D., Cope, B., Kalantzis, M., Castro, V., Kourkoulou, T., Jones, J., da Silva, R. A., Whiting, J., & Kastania, N. P. (2023). Generative AI : Implications and Applications for Education (arXiv:2305.07605). arXiv. https://doi.org/10.48550/arXiv.2305.07605

Pack, A., & Maloney, J. (2023). Using Generative Artificial Intelligence for Language Education Research : Insights from Using OpenAI's ChatGPT. TESOL Quarterly, 57(4), 1571-1582. https://doi.org/10.1002/tesq.3253

Trust, T., Whalen, J., & Mouza, C. (2023). Editorial : ChatGPT: Challenges, Opportunities, and Implications for Teacher Education. Contemporary Issues in Technology and Teacher Education, 23(1), 1-23.

Van Campenhout, R., Hubertz, M., & Johnson, B. G. (2022). Evaluating AI-Generated Questions : A Mixed-Methods Analysis Using Question Data and Student Perceptions. In M. M. Rodrigo, N. Matsuda, A. I. Cristea, & V. Dimitrova (Éds.), Artificial Intelligence in

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Education (p. 344-353). Springer International Publishing. https://doi.org/10.1007/978-3-031-11644-5_28

Zhai, X., & Nehm, R. H. (2023). AI and formative assessment: The train has left the station. Journal of Research in Science Teaching, 60(6), 1390-1398. https://doi.org/10.1002/tea.21885

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

A Methodological Framework for Survey Design: Investigating Perceptions of Product Sustainability - A Case Study

Svenja Hauck[a], Lucas Greif[a] and Kim Skade[a]

[a]Institute for Information Management in Engineering, Karlsruhe Institute of Technology, Germany

Abstract

In response to increasing environmental challenges and initiatives, understanding perception and knowledge of sustainability has become crucial in shaping effective policies and educational strategies. Although there are numerous sustainability surveys, there is a scarcity of literature that focuses on the methodological framework and best practices in survey design specifically tailored to the context of environmental sustainability. This study aims to fill this gap by providing a detailed guide on how to approach the assessment of the understanding of sustainability. By focusing on the automotive industry in Germany, a sector pivotal to both the economy and environmental policymaking, we offer a case study that illustrates the intricacies and considerations necessary to design an effective and meaningful survey. This research serves as a foundational reference for future studies exploring similar thematic areas.

Keywords: survey; framework; environmental sustainability; perception of sustainability.

How to cite: Hauck, S.; Greif, L. and Skade, K. (2024) A Methodological Framework for Survey Design: Investigating Perceptions of Product Sustainability – A Case Study. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 699-707. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction and motivation

Promoting sustainable development represents a central challenge in the 21st century. Various political initiatives have been introduced to promote this sustainable development. Among the most prominent is the United Nations Agenda 2030, which provides a comprehensive framework to achieve this goal by setting 17 Sustainable Development Goals (SDGs) (Summit Charts New Era of Sustainable Development, 2015). These goals encompass ecological, social, and humanitarian dimensions.

Understanding the perception and knowledge of sustainability is crucial in shaping effective policies and educational strategies. One way to measure this knowledge is through surveys. Several guidelines on the preparation of a survey have been published applying different foci, such as academic success (Raab-Steiner et al., 2018), professional success and social background (Kromrey et al., 2016) but the application examples in these guidelines for the topic of sustainability are limited.

This gap of examples could be filled with several studies conducted on the greater topic of sustainability. The surveys analyze public perception about environmental awareness (Geiger & Holzhauer, 2020), environmental protection (Bodensteiner et al., 1997), transformation of life through environmental sustainability (Pfnür, 2022) and sustainable consumption in Germany (Carl von Ossietzky Universität Oldenburg, 2014; McKinsey, 2021; Rehberg, 2006).

Despite the large number of studies on the topic of sustainability, these studies reveal disadvantages in the methodology of the structure of the questionnaire or its implementation. Surveys with only a few questions (Carl von Ossietzky Universität Oldenburg, 2014; Hischemöller, 2019) are leading to limited results for researchers on the background and reasons for the answers. Other studies were intended to reflect certain statistical quota in the distribution of respondents by age, gender, and household income, but were not followed in implementation (Bodensteiner et al., 1997).

This study aims to fill this gap by providing a detailed guide on how to approach the assessment of understanding of environmental sustainability. By focusing on the automotive industry in Germany, a sector pivotal to both the economy and environmental policymaking, we offer a case study that illustrates the intricacies and considerations necessary in designing a survey that is both comprehensive and sensitive to the nuances of perception in this field.

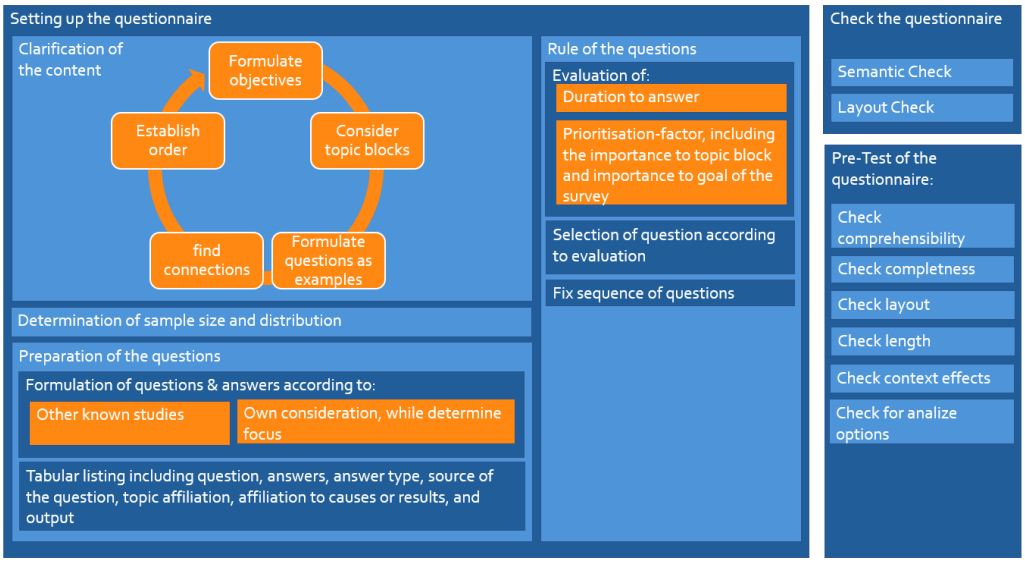
In doing so, our goal is to contribute to the broader discourse on sustainable development, providing researchers, policymakers, and educators with a robust framework to assess and understand public knowledge and attitudes toward sustainability, ultimately aiding in the development of more informed and effective environmental policies and educational programs.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. Methodological framework

The preceding section highlighted the existence of guides for survey creation, but noted a scarcity of comprehensive examples specifically addressing the topic of sustainability and that transferability to this is difficult. Consequently, this work aims to establish a more robust and comprehensive framework (see Figure 1) for the construction of sustainability-focused surveys. It delineates components directly sourced from existing literature, although some of these only appear in isolated sources; where no literature is specified, it elucidates segments that have been specifically tailored or developed to suit the unique demands of sustainability topics, resulting in a more holistic framework. This adaptation aims to rectify the limitations commonly encountered in existing sustainability surveys.

Fig. 1– Methodological framework to create a survey on the topic of sustainability



Source: own elaboration

The framework is composed of three primary segments. The first segment, positioned in the upper left corner, is designated as "**Setting up the Questionnaire**". This foundational block is further subdivided into four distinct steps: clarifying the content, determining the sample size and distribution, preparing the questions and establishing their sequence.

Clarifying the content is represented as a circular flow that includes five sequential stages. These include:

- **Formulate Objectives:** This involves defining clear goals for the survey. Questions such as "What do we want to know at the end of the survey?" help to sharpen the focus of the objectives (Raab-Steiner et al., 2018).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

- **Consider Topic Blocks:** Here, individual topics of interest are identified, posing the question "Which individual topics do we want to know something about?" (Kromrey et al., 2016).
- **Formulate Questions as Examples:** This stage involves creating potential questions for each topic block to explore its aspects.
- **Find Connections:** This involves examining the relationships between various topics (Kromrey et al., 2016; Mayer, 2013).
- **Establish Order:** The final step involves arranging thematic blocks in a logical sequence (Kromrey et al., 2016) of causes and effects. The goal of the survey is to examine the effects. However, examining the causes helps to draw conclusions later.

The cyclical nature of these steps reflects the evolving clarity of the objectives as one delves deeper into the topic of sustainability. This iterative process can lead to the discovery of new and relevant topic blocks, enriching the questionnaire. Using a visualization tool in this process is highly beneficial.

Determination of Sample Size and Distribution includes methodologies and strategies to select the appropriate sample size for the survey, as well as the distribution methods to be used. This step ensures that the survey reaches a representative and adequately sized segment of the target population, crucial for the validity and reliability of the survey (Kromrey et al., 2016; Raab-Steiner et al., 2018; Schumann, 2012) .

The **Preparation of the questions** is divided into two main categories: formulation of questions with predefined answers and their tabular listing. For the formulation of questions, there are two primary sources: replicating questions from similar reference studies (Raab-Steiner et al., 2018; Schumann, 2012) or crafting original questions based on one's own research (Raab-Steiner et al., 2018). It is important to define the focus area of each question, keeping in mind the type of question being asked and the possible responses allowed. To enhance clarity in question presentation, a tabulated format is recommended. This table should include columns for the question, possible answers, answer type, question source (copy or own formulation), topic affiliation, relevance to causes or results, and the potential outputs derivable from each question.

The **Consideration of the Rules of the Questions** is segmented into three tasks:

- **Evaluation of Each Question:** This involves assessing the time required to answer each question and assigning a prioritization factor. This factor aggregates two evaluations: the question's relevance to the specific topic block and its significance in achieving the survey's overall goal.
- **Selection of Questions Based on Evaluation:** The gathered evaluations serve as a guide for selecting questions, with the aim of balancing the length of the

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

questionnaire with the maximization of informative results. When comparing the duration estimates of each topic block with their prioritization factors, it becomes feasible to streamline the questionnaire, potentially reducing or eliminating certain questions within specific topic blocks.

- **Finalizing the Question Sequence:** The arrangement of the questions is critical and should follow a logical progression within the context of the topic blocks (Baur & Blasius, 2014; Kromrey et al., 2016; Theobald, 2017). The sequence should ideally transition from general to more specific queries within each block, ensuring a coherent and intuitive flow for respondents.

The **Check of the Questionnaire**, located in the upper right corner, represents the second major segment of the framework. It is divided into two critical subtasks: the Semantic Check and the Layout Check, both essential to ensure the quality and effectiveness of the questionnaire.

- **Semantic check:** This task involves a thorough review of the formulation of the questions. It emphasizes the importance of using a clear, concise, and neutral language. Furthermore, this check extends to the proposed answers, scrutinizing them for clarity and neutrality to avoid bias or misinterpretation (Iarossi, 2006; Kromrey et al., 2016; Raab-Steiner et al., 2018). This step is crucial to ensure that the questionnaire accurately captures the information it seeks without leading or confusing the respondent.
- **Layout Check:** This check focuses on the general presentation of the questionnaire, including the sequence of questions (Iarossi, 2006; Kromrey et al., 2016; Raab-Steiner et al., 2018). Assess the visual layout, ease of navigation through the questionnaire and logical order of the questions to facilitate smooth flow and minimize the fatigue or confusion of the respondents.

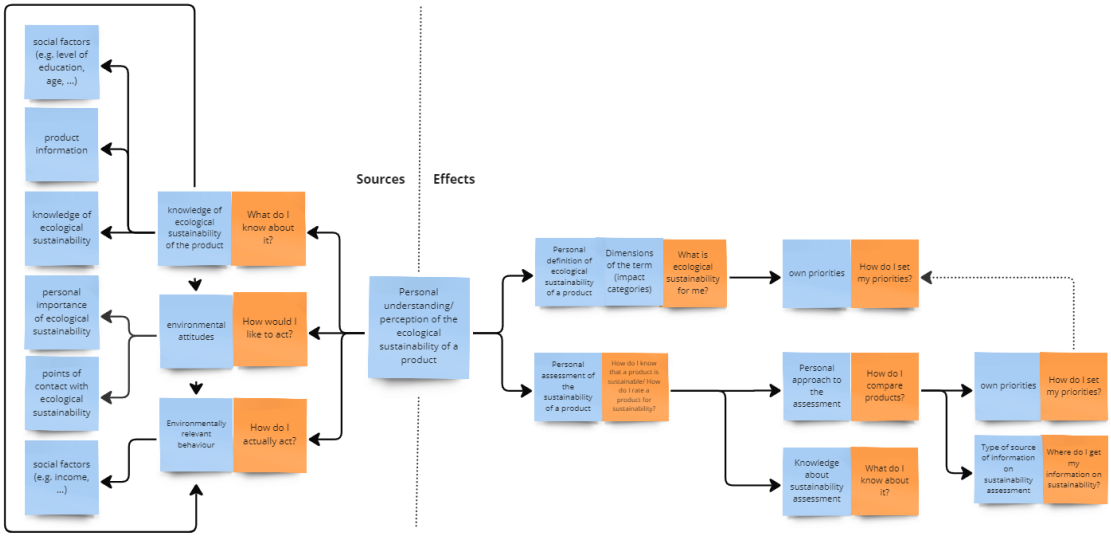
The **Pre-test of the Questionnaire** forms the final major segment of the framework. The pre-test is essentially a pilot study conducted prior to the main survey. The primary objectives of the questionnaire are to evaluate the clarity, completeness and overall effectiveness of the questionnaire. The key aspects evaluated in the pre-test include the length of the questionnaire, the suitability of the layout, the identification of potential context effects, the appropriateness of the response frequency distribution, and the feasibility of conducting the desired analysis with the chosen response formats (Hollenberg, 2016; Porst, 2014; Raab-Steiner et al., 2018). This stage is instrumental in identifying and rectifying any issues before the questionnaire is administered on a larger scale, ensuring that the final survey is reliable and valid.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Applying the Framework to "Understanding Ecological Sustainability of Products"

This section outlines the application of our framework in constructing a survey focused on "Understanding the Environmental Sustainability of Products". The survey will be conducted within the research project IntWertL[1]. This is the reason for the focus on the automotive industry.

Fig. 2 – Clarification of the content for the application of the framework to the topic of "Understanding of the ecological sustainability of products"



Source: own elaboration

Initially, we used the "Miro" visualization tool for content clarification, participating in iterative task cycles to produce the mind map depicted in Figure 2. This mind map features our research focus: individuals' perceptions of a product's ecological sustainability. Thematic blocks surrounding this, such as ecological knowledge and behavior with environmental relevance, are displayed in blue. Each block is paired with detailed questions (illustrated in orange) to foster a unified understanding. Arrows indicate interconnections and dependencies among topics. For example, the "Personal assessment of a product's sustainability" is broken down into the "Knowledge level on sustainability assessment" and the "Personal assessment approach". The topic "Personal priorities" is shown twice for clarity, linked by a dashed line. The mind map is bifurcated into left and right sections to distinguish sources from effects.

The subsequent phase involves the finalization of the questionnaire. Several questions, especially those on "knowledge classification", "environmentally relevant behavior", and

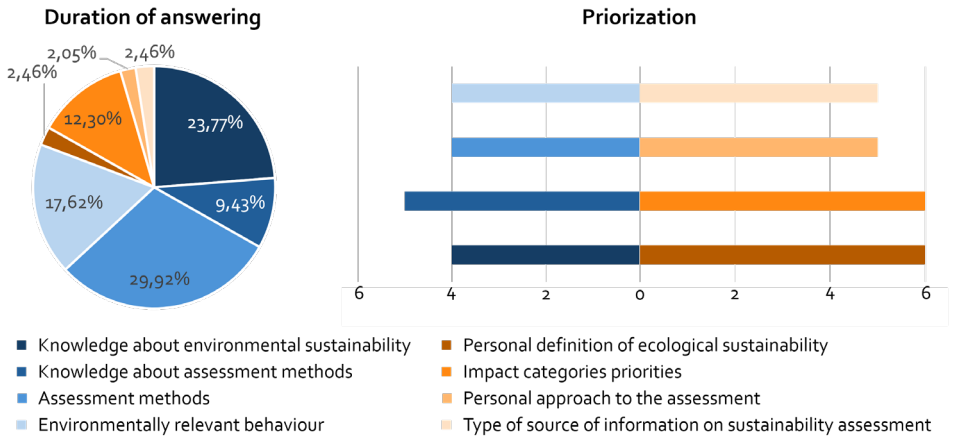
[1] Intelligent value networks for lightweight vehicles in small quantities (German: Intelligente Wertschöpfungsnetzwerke für Leichtbaufahrzeuge geringer Stückzahl)

2024, Editorial Universitat Politècnica de València BY-NC-SA

"personal values", are adapted from smaller but relevant studies (Bodensteiner et al., 1997; Geiger & Holzhauer, 2020). New questions are crafted based on all identified topics, with a focus on electric vehicles. For example, the impact categories are queried using an application example on this topic instead of abstract phrasing. Responses range from checkboxes and scales to open-ended answers. The questionnaire, which contains 69 questions, was organized using "Excel." Each question was also rated for response time from one (quick) to three (slow), and for the priorization-factor, an accumulation of the factors for relevance to the specific topic block and for significance in achieving the survey's overall goal, each from three (highly important) to one (less important), leading to a range from two (low priority) to six (high priority).

Figure 3 presents a comparison of the duration and priority of the questions for each topic block. It features two charts: one for duration as a percentage of total survey time, and another for priority, depicted as a double-sided bar chart normalized by question count. This analysis helps identify topics for potential reduction to streamline the questionnaire. For example, a topic of high duration but low importance might see a reduction in questions.

Fig. 3 – Comparison of the duration to answer and the priority of each topic block of the application of the framework to the topic of "Understanding the ecological sustainability of products"



Source: own elaboration

The questionnaire sequence follows the logical order of topics: sustainability knowledge, environmental attitudes, relevant behaviors, personal definitions of product sustainability, and the assessment of the same. The questions transition from general to specific, eventually relating to electric vehicles. Related questions are grouped to maintain thematic coherence. The final stages of questionnaire refinement and pre-testing adhere to the framework's further development guidelines.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Discussion and outlook

The study has the potential to have significant implications in both the theoretical and practical realms. First, it contributes to the expanding body of knowledge on survey methodologies, especially in the context of environmental sustainability. It expands the existing literature that often concentrates on specific aspects of survey design by providing an overall framework of the steps and considerations necessary to design an effective and meaningful sustainability-focused survey. This research can serve as a foundational reference for future studies exploring similar thematic areas.

On the practical side, it can streamline survey design and ensure the creation of better surveys, especially in contexts where knowledge about survey design is limited. Furthermore, in the long-term perspective, the development of better surveys can facilitate a more precise understanding of public perceptions of sustainability. This improved knowledge could then guide policymakers in formulating guidelines that encourage both industry and consumers to make choices that are more aligned with sustainability principles.

However, the effectiveness of the framework in generating improved results has not yet been proven. Therefore, future research should aim to quantitatively validate whether the application of the proposed framework leads to enhanced survey outcomes.

Acknowledgements

The research is funded by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) in research project IntWertL (No. 19S22003Q).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Baur, N., & Blasius, J. (2014). Handbuch Methoden der empirischen Sozialforschung. Springer.

Bodensteiner, G., Spiller, A., & Elbers, H. (1997). Strategische Konsumentscheidungen : langfristige Weichenstellungen für das Umwelthandeln ; Ergebnisse einer empirischen Studie.

Carl von Ossietzky Universität Oldenburg. (2014). Ergebnisse der Umfrage zum Kauf von nachhaltigen Produkten im Internet. https://uol.de/f/2/dept/wire/fachgebiete/entrepreneur/download/presse/Umfrage_zum_Kauf_von_nachhaltigen_Produkten_im_Internet_Auswertung.pdf

2024, Editorial Universitat Politècnica de València BY-NC-SA

Geiger, S., & Holzhauer, B. (2020). Weiterentwicklung einer Skala zur Messung von zentralen Kenngrößen des Umweltbewusstseins. Umweltbundesamt. http://www.umweltbundesamt.de/publikationen

Hischemöller, M. (2019). UMFRAGE ZUM THEMA NACHHALTIGKEIT. https://www.frankfurt-main.ihk.de/blueprint/servlet/resource/blob/5298290/7ff8e6195679d650c4e37617e118c6oe/umfrage-zum-thema-nachhaltigkeit-data.pdf

Hollenberg, S. (2016). Fragebögen. Springer VS.

Iarossi, G. (2006). The Power of Survey Design, A User´s Guide for Managing Surveys, Interpreting Results, and Influencing Respondents. The World Bank.

Kromrey, H., Roose, J., Strübing, J. (2016). Empirische Sozialforschung Modelle und Methoden der standardisierten Datenerhebung und Datenauswertung mit Annotationen aus qualitativ-interpretativer Perspektive (13th ed., Vol. 1). UVK Verlagsgesellschaft mbH.

Mayer, H. O. (2013). Interview und schriftliche Befragung Grundlagen und Methoden empirischer Sozialforschung (6th ed.). Oldenbourg Verlag München .

McKinsey&Company. (2021). The survey assesses consumer sentiment and behavior regarding sustainability and FMCGs before, during and after COVID-19 crisis. https://www.mckinsey.com/de/~/media/mckinsey/locations/europe%20and%20middle%20east/deutschland/news/presse/2021/2021%20pm%20nachhaltiger%20konsum/studie-nachhaltiger-konsum.pdf

Pfnür, A., Bachtal, Y. Voll, K. Gauger, F. (2022). Arbeitspapiere zur immobilienwirtschaftlichen Forschung und Praxis (Vol. 45). Technische Universität Darmstadt.

Porst, R. (2014). Fragebogen: Ein Arbeitsbuch. Springer.

Raab-Steiner, E., Benesch, M. (2018). Der Fragebogen von der Forschungsidee zur SPSS-Auswertung (5th ed., Vol. 1). facultas Universitätsverlag.

Rehberg, K.-S. (2006). Soziale Ungleichheit, kulturelle unterschiede: Verhandlungen des 32. Kongresses der Deutschen Gesellschaft für Soziologie in München. Campus Verlag.

Schumann, S. (2012). Repräsentative Umfrage Praxisorientierte Einführung in empirische Methoden und statistische Analyseverfahren (6th ed.). Oldenbourg Verlag München

Summit Charts New Era of Sustainable Development. (2023). Retrieved January 4, 2024, from https://www.un.org/sustainabledevelopment/blog/2015/09/summit-charts-new-era-of-sustainable-development-world-leaders-to-gavel-universal-agenda-to-transform-our-world-for-people-and-planet/

Theobald, A. (2017). Praxis Online-Marktforschung. Springer Gabler.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Assessing digitalization in personnel management: a systematic approach and case study

Valērijs Dombrovskis[a], Aleksandrs Skvorcovs[b]

[a]PhD student at the University of Daugavpils, lecturer and director of the bachelor's program "Business Psychology", RISEBA University of Applied Sciences, Riga, Latvia.

[b]Lecturer and director of the bachelor's program "Business Management", RISEBA University of Applied Sciences, Riga, Latvia.

Abstract

This article presents a practical instance of applying theoretical knowledge to assess an organization's digital readiness in personnel management, highlighting the importance of a systematic approach in the digital age. It outlines six key stages of assessment, with a focus on digital competencies, work environment, and software evaluation, culminating in a comprehensive improvement plan. The inclusion of a seventh stage emphasizes the need for ongoing software comparison and adaptation. The findings advocate for incorporating this systematic methodology into university curricula to prepare future leaders for effective digital transformation management in organizations.

Keywords: digitalization; personnel management; systematic approach; digital competencies; future leaders education.

How to cite: Dombrovskis, V. and Skvorcovs, A.(2024) Assessing digitalization in personnel management: a systematic approach and case study. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 708-718. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The need to educate future leaders in assessing personnel management digitalization is crucial, especially in light of the accelerated digital shift propelled by the COVID-19 pandemic and the transition to remote work models. Studies by Kuzior et al. (2022) and Valenduc (2017) highlight the ongoing evolution of digitalization, while the pandemic's impact underscores the importance of digital proficiency in leadership (Длугопольська, 2021). Remote workforce management has turned digitalization in personnel management from an operational need to a strategic necessity for maintaining business continuity and resilience (Rostoka, 2022; Minbaeva, 2021). Supported by Bapic (2022), this shift necessitates integrating the evaluation of digitalization within leadership training, preparing future leaders to lead digital transformations effectively and maintain organizational flexibility and resilience.

2. Literature Review

2.1 Digitization of personnel management

Digital transformation, a key trend affecting businesses and society, embodies a new cultural system based on ideals and knowledge. To remain competitive, organizations worldwide are undergoing significant operational changes by adopting digital transformation (Kohli, 2019; Schildt, 2022). Theoretical models identify two main digitalization strategies: a comprehensive approach and a targeted approach.

The comprehensive strategy involves embedding digital processes within the broader context of digital transformation in business, aiming for complete digital integration through data and information systems for enhanced control (Parviainen et al., 2017; Schallmo & Williams, 2018; Bloomberg, 2018; Rachinger et al., 2019; Wessel et al., 2021; Schildt, 2022).

Shifting to a targeted strategy, the focus narrows to improving digitalization in personnel management (Halid, 2020; Rachinger, 2019; Bumann, 2019; Reis et al., 2019). This shift requires not just new technologies but also adjustments in organizational structure and management tactics for effective digital integration. This leads to a closer examination of "Types of Digitalization in Personnel Management," outlined in the upcoming Table 1, which organizes digitalization strategies within personnel management to illustrate how digital initiatives correspond with both operational and strategic goals in personnel management.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 2 – Personnel management digitalization types

Type	The aim
Non-application of digitalization	This category lacks digital support, indicating no requirement for digitalization in personnel management practices or strategies.
Operational application of digitalization	Digitalization here aims to enhance operational efficiency in personnel management by automating processes to increase speed, reduce costs, and improve quality.
Strategic alignment of digitalization	Digital tools are utilized post-strategy formulation to support the execution of personnel management strategies, focusing on areas like recruitment and employee development.
Strategic Integration of digitalization	Digital technologies are incorporated from the strategy formulation stage to systematically enhance personnel management and foster beneficial relationships with employees.

Source: Strohmeier (2020)

Understanding the alignment of digitalization strategies with personnel management objectives is key to adding organizational value. Early integration of digitalization in strategic planning is crucial for developing digital competencies and training (Strohmeier, 2020; Różewbski, 2019; Bumann, 2019), enhancing process efficiency and making the company a desirable employer, thus underscoring the need for digitalization assessment in personnel management for maintaining competitiveness.

2.2 Stages of assessing the level of digitalization of personnel management

The "Human Resources Management" course at RISEBA University of Applied Sciences emphasizes training future leaders to systematically assess digitalization in personnel management. This module covers assessment stages, equipping students to analyze and implement digital strategies in personnel functions effectively. Graduates are thus prepared to lead digital transformations, nurturing leaders skilled in using technology to improve personnel management. Let's explore the assessment stages taught to these future leaders.

The six stages of assessment for digitalization in personnel management, focus on various key areas essential for evaluating and enhancing digital personnel management practices. These stages include:

1. Assessment and comparison of personnel digital competencies (Halid, 2020) - evaluating the digital skills of the workforce and comparing these against industry standards or benchmarks to identify gaps and training needs.
2. Digital work environment assessment (Rachinger, 2019) - examining the technological infrastructure and tools available to employees for performing their tasks effectively in a digital context.

2024, Editorial Universitat Politècnica de València BY-NC-SA

3. Personnel management software evaluation (Bumann, 2019) - reviewing the personnel management software solutions in use for their effectiveness in managing personnel data, processes, and workflows.
4. Identification of digital personnel management software improvement needs (Reis et al., 2019) - identifying areas where existing personnel management software requires enhancements or updates to meet current digital personnel needs.
5. Establishment of key indicators and factors for digital personnel management software improvement (Strohmeier, 2020) - setting benchmarks and criteria for selecting the best software solution based on the organization's specific personnel management digitalization goals.
6. Development of a digital personnel management improvement plan (Kohli, 2019) - creating a strategic plan to implement the selected software solutions and practices to improve digital personnel management.

These stages are integral to a systematic approach for assessing and improving digitalization in personnel management, ensuring that personnel management functions are efficiently and effectively aligned with modern digital standards.

The preceding information sets the stage for a practical application of the theoretical concepts explored. In the practical section that follows, we will present an assessment conducted by a student on the readiness of AS "Kalceks," one of the oldest pharmaceutical companies in the Baltic countries, for digitalization in personnel management. This example will illustrate the practical implications of digitalization assessment in a real-world organizational context, highlighting the intersection between academic theory and practical application in the field of personnel management digitalization.

3. Research methodology

The research methodology encompassed a mixed-methods approach, focusing on qualitative techniques for both primary and secondary data collection. The goal was to evaluate the existing state of digitalization readiness in personnel management at JSC "Kalceks" and to identify optimal digital tools for its implementation. This thorough approach offered a detailed insight into the organization's preparedness for digital transformation in personnel management. The outcomes were detailed according to a six-stage framework for evaluating digitalization in personnel management.

3.1 First stage "Assessment and comparison of personnel digital competencies"

In the first stage, the student applied the European Commission's digital competencies framework, addressing five areas: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety, and Problem Solving. A self-assessment survey with 82 items was administered to JSC "Kalceks" employees, using a Likert scale for

BY-NC-SA 2024, Editorial Universitat Politècnica de València

responses. The analysis via SPSS showed high internal reliability (Cronbach's alpha = 0.922) and normal distribution. Results highlighted strengths in Information and Data Literacy and areas for improvement in Digital Content Creation. For an objective assessment, self-assessment results were compared with an analysis of personnel files, focusing on digital competencies required by the company for each position. This comparison, shown in Table 2, was done in collaboration with the personnel management department to determine average competency levels per role, reflecting job descriptions, job postings, and digitalization needs, ensuring a thorough evaluation while protecting personal data confidentiality

Table 2 – Average overall digital competency levels comparison

Position	Self-assessment questionnaire results	Result of personal affairs analysis
Chairman of the Board	2.68	2.70
Lawyer	2.38	2.75
Economist	3.44	2.90
Chief Accountant	2.15	2.80
Accountant	2.95	2.75
Office Administrator	2.91	2.75
Office Administrator - Clerk	2.67	2.85
Office and Personnel Manager	3.01	3.12
IT Specialist	3.39	3.30
Economic Manager	2.06	2.50
Technical Manager	1.84	2.07
Commercial Director	3.11	2.77
Planning Department Manager	2.85	2.83
Logistics and Customer Service Specialist	2.51	2.83
Customer Service and Planning Specialist	2.90	2.87
Regional Manager	3.07	2.98
Product Implementation Specialist	3.00	2.95
Market Analyst	3.78	3.33
Quality and Development Department Director	2.95	2.75
Registration Department Manager	2.68	2.75
Registration Project Manager	2.66	2.80
Designer - Layout Artist	3.23	3.08
Quality Assurance Specialist	2.71	2.85
Qualified Person	2.95	2.83
Development Department Manager	2.84	3.05
Development Project Manager	2.87	2.83
Drug Registration Specialist	2.73	2.82

Source: Own elaboration

To understand the results of the digital competencies assessment, it's important to note the evaluation coefficients used: a score of 0–1 indicates a lack of digital competencies; 1–2 suggests partial competencies that are inadequate without assistance; 2–3 denotes convincing competencies, where individuals are confident in their skills and can effectively use necessary tools and information; and 3–4 represents exceptional digital competencies, with individuals capable of independent application and teaching others.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The table indicates that 44% of survey participants believe their digital skills are below the level needed for their job tasks, while 56% feel their skills exceed expectations. This discrepancy is highlighted in Table 3, where roles like market analysts rate their skills higher than the job requirements suggest. To ensure objectivity, the study used the lower of the two comparison values for each employee. A significant majority, 89%, demonstrated competent use of digital technologies, indicating the need for only a small percentage to improve their digital skills to meet the demands of a digitized personnel management system. The subsequent focus was JSC "Kalceks"'s work environment, assessing device and software sufficiency for job duties and digital skill facilitation.

3.2 Second stage "Digital work environment assessment"

In the subsequent stage, the focus was on evaluating the digital work environment readiness at JSC "Kalceks". This involved conducting focus group interviews with department heads to delve into the nuances of workplace digitalization, specifically from the viewpoint of prospective users of digital personnel management software. The assessment scrutinized the adequacy of devices, access, networks, and software essential for employees to fulfill their roles and effectively leverage their digital skills. The summarized outcomes, presented in a table 3, depicted the readiness of the company's work environment for digitalization, based on the availability of digital tools.

Table 3 – JSC "Kalceks" digital work environment diagnostic indicators

Indicator	Employee proportion	Conclusion
Laptop provision	100%	The company has provided laptops to all employees so that everyone can participate in company processes and information exchange.
Corporate network access	98.4%	Almost all employees in the company are involved in the corporate information space. One employee has limited access to this network, which is due to a lack of equipment.
Company internet access	98.4%	A high number of employees have internet access. Only one out of 62 employees does not have a permanent workplace, and therefore, no internet access is provided.
Desktop devices provision	98.4%	61 out of 62 company employees have workplaces equipped with desktop devices, including docking stations, monitors, and network access.
Remote work opportunities	95.2%	58 out of 62 (which is 95.2%) company employees can fully perform their job duties remotely, and this option is provided to them.
Corporate mobile communications	41.9%	Less than half of the employees in the company, specifically 26 out of 62 employees, are connected to corporate mobile communications.

Source: Own elaboration

The evaluation of JSC "Kalceks"' digital work environment reveals a high readiness for digital personnel management, with most indicators showing favorable conditions. The next focus for assessing the company's digital personnel management level will be its digital management software.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.3 Third stage "Personnel management software evaluation"

The assessment of digital personnel management involves determining the level of digitization in personnel management processes, focusing on the existence of a unified, coordinating information software. In the next stage of the research, the student conducted interviews with the IT specialist at JSC "Kalceks" to assess the digitization level in personnel management, focusing on the use of digital tools and software for operational processes. This step aimed to understand the integration of unified, coordinating information software and its impact on personnel management. The assessment of JSC "Kalceks" digital personnel management software is encapsulated in Table 4, highlighting key diagnostic indicators essential for understanding the company's digital infrastructure readiness for personnel management.

Table 4 – JSC "Kalceks" digital personnel management software diagnostic indicators

Indicator	Result	Conclusion
Management System availability	Does not exist	The company does not have a unified management information system that integrates all company processes.
Personnel management module count	2	At the time of development, the company's personnel management system consists of 2 personnel management modules: Employee Central and Work Zone.
Digitized process block ratio	33.3%	As of the development stage, the company has digitized 3 out of 9 personnel management process blocks: personnel records, self-service platform, and communication tools.
Employee decision influence rate	17.7%	Decisions in the company are made by 4 out of 62 employees: the chairman of the board, the chief accountant, the director of the quality and development department, and the commercial director, but the number of employees influencing decisions is higher: 11 out of 62.
Managerial staff ratio	12.9%	Out of all the employees in the company, 8 are managers in the company's organizational units.

Source: Own elaboration

The study's author assessed JSC "Kalceks" current personnel management digitalization level, highlighting the need for a comprehensive management software integration. The findings suggest a move towards a more inclusive decision-making process and an expansion of personnel management software modules to enhance transparency and efficiency in personnel management. This approach aims to better align the digital personnel management tools with the company's strategic goals and operational needs.

3.4 Fourth stage "Identification of digital personnel management software improvement needs"

In the subsequent stage of the research, the student conducted a detailed interview with JSC "Kalceks'" personnel and office manager to identify the company's digital personnel management software improvement needs. This part of the study, informed by the challenges brought to light by the COVID-19 pandemic, such as difficulties in onboarding and

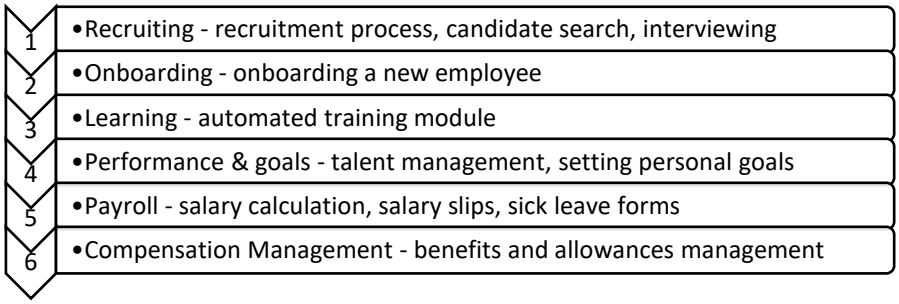
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

communication, revealed the partial utilization of existing personnel management software and the continued reliance on manual processes. The findings emphasized the necessity for a comprehensive, integrated digital platform that enhances efficiency, ensures data security, adheres to local regulations, and fosters employee engagement.

3.5 Fifth stage "Establishment of key indicators and factors for digital personnel management software improvement"

Before creating a plan for improving digital personnel management software, it's vital to consider all influencing factors. Based on interviews with the personnel and office manager, as well as the company's president, the initial step is to prioritize personnel management modules for implementation according to their urgency. The most crucial aspect for the company JSC "Kalceks " is streamlining the recruitment processes.

Fig. 1 – SAP SuccessFactors personnel management modules arranged by priorities



Sources: Sanyaolu, & Atsaboghena (2022); Garg, et al. (2022)

The study highlighted the necessity for JSC "Kalceks" to prioritize the implementation of personnel management modules due to challenges in remote recruitment processes. The first essential module is recruitment and interviewing, followed by new employee onboarding, training, talent management, and finally compensation management. The implementation of the first two modules took 8 months, suggesting a total of 24 months for all six. Costs, shared with the parent company "Grindeks," and implementation time are critical factors, with each module costing €50,950 and a yearly subscription fee of €9 per employee per module.

3.6 Sixth stage "Development of a digital personnel management improvement plan"

In the concluding stage, a detailed plan was formulated to enhance the digital personnel management software at JSC "Kalceks." This plan was based on insights gathered from interviews with the company's key stakeholders. It proposed a phased rollout of SAP SuccessFactor modules, prioritizing those that address recruitment processes, identified as a critical area for improvement. The plan spans an estimated 24 months and includes comprehensive financial forecasts for the adoption and ongoing use of each module. This

BY-NC-SA 2024, Editorial Universitat Politècnica de València

strategic blueprint aims to refine personnel management workflows, boost employee engagement, and support the company's overarching objectives, all while maintaining the confidentiality of specific plan elements.

Conclusions

This article provides a concise overview of a practical case where students evaluate the digitalization level in personnel management, emphasizing the criticality of a systems approach in today's digital era. The investigation into digitalization within personnel management underscores the indispensability of a structured methodology. The delineation of six phases-evaluation and comparison of digital competencies within the workforce, analysis of the digital work environment, appraisal of personnel management software, pinpointing the improvement necessities for digital personnel management software, establishing pivotal indicators and factors for enhancement, and formulating an augmentation plan-elucidates the complexity inherent in digital transformation. The incorporation of a seventh phase, "Comparison of digital personnel management improvement software" prior to establishing key indicators, accentuates the imperative for ongoing assessment and refinement. Imparting knowledge of these systematic methodologies to prospective leaders at the tertiary education level is vital for equipping them to adeptly steer and implement digital transformations, thereby ensuring organizational agility and competitiveness in a dynamically evolving digital milieu.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bloomberg, J. (2018). Digitization, digitalization, and digital transformation: confuse them at your peril. Forbes. Retrieved on August, 28, 2019.

Bumann, J., & Peter, M. (2019). Action fields of digital transformation–a review and comparative analysis of digital transformation maturity models and frameworks. *Digitalisierung und andere Innovationsformen im Management. Innovation und Unternehmertum*, *2*, 13-40.

Garg, S., Sinha, S., Kar, A. K., & Mani, M. (2022). A review of machine learning applications in human resource management. *International Journal of Productivity and Performance Management*, 71(5), 1590-1610.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Halid, H., Yusoff, Y. M., & Somu, H. (2020, May). The relationship between digital human resource management and organizational performance. In *First ASEAN Business, Environment, and Technology Symposium (ABEATS 2019)* (pp. 96-99). Atlantis Press.

Kohli, R., & Melville, N. P. (2019). Digital innovation: A review and synthesis. *Information Systems Journal*, *29*(1), 200-223.

Kuzior, A., Kettler, K., & Rąb, Ł. (2022). Digitalization of Work and Human Resources Processes as a Way to Create a Sustainable and Ethical Organization. Energies, 15(1), 172. https://doi.org/10.3390/en15010172

Minbaeva, D. (2021). Disrupted HR?. *Human Resource Management Review*, *31*(4), 100820.

ORACLE. (2023). Oracle Human Capital Management. Retrieved from https://www.oracle.com/human-capital-management/#rc30p1

Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. *International journal of information systems and project management*, *5*(1), 63-77.

Rachinger, M., Rauter, R., Müller, C., Vorraber, W., & Schirgi, E. (2019). Digitalization and its influence on business model innovation. Journal of Manufacturing Technology Management, 30(8), 1143-1160. https://doi.org/10.1108/JMTM-01-2018-0020

Reis, J., Amorim, M., Melão, N., Cohen, Y., & Rodrigues, M. (2020). Digitalization: A literature review and research agenda. In *Proceedings on 25th International Joint Conference on Industrial Engineering and Operations Management–IJCIEOM: The Next Generation of Production and Service Systems 25* (pp. 443-456). Springer International Publishing.

Rostoka, Z. (2022). *Digitāla personāla vadība* (1. daļa) VISMA. Latvijas Personāla vadīšanas asociācija. Retrieved from https://lpva.lv/articles/347/digitala-personala-vadiba-1-dala-visma

Sanyaolu, E., & Atsaboghena, R. (2022). Role of Artificial Intelligence in Human Resource Management: Overview of its benefits and challenges. ResearchGate, (December), 1-8.

Schallmo, D. R., & Williams, C. A. (2018). *Digital transformation now!: Guiding the successful digitalization of your business model*. Springer.

Schildt, H. (2022). The Institutional Logic of Digitalization. In Digital Transformation and Institutional Theory (Research in theSociology of Organizations, Vol. 83 (pp. 235-251). Bingley: Emerald Publishing Limited. https://doi.org/10.1108/S0733-558X20220000083010

Strohmeier, S. (2020). Digital human resource management: A conceptual clarification. *German Journal of Human Resource Management*, 34(3), 345-365. https://doi.org/10.1177/2397002220921131

Udovita, P. V. M. V. D. (2020). Conceptual review on dimensions of digital transformation in modern era. *International Journal of Scientific and Research Publications*, *10*(2), 520-529. Valenduc, G., & Vendramin, P. (2017). Digitalisation, between disruption and evolution. *Transfer: European Review of Labour and Research*, *23*(2), 121-134.

Варс, І.О., Кравчук, О.І., & Паращук, Є.Ю. (2022). Цифровізація бізнес-процесів менеджменту персоналу: можливості HRM-систем. *Галицький економічний вісник*, 74(1), 90-102.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Длугопольська, Т.І., & Гук, Ю.В. (2021). Цифрова трансформація у сфері hr: напрями, проблеми та можливості. Collection of Scientific Papers of the Cherkasy State University of Technology. Series: Economic Sciences, (66), 13-18.

Wessel, L., Baiyere, A., Ologeanu-Taddei, R., Cha, J., & Blegind-Jensen, T. (2021). Unpacking the difference between digital transformation and IT-enabled organizational transformation. Journal of the Association for Information Systems, 22(1), 102-129.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Active Blended Learning of Industry 5.0-Oriented Sustainable Power Engineering Specialists

Valery Vodovozov[a], Zoja Raud[a] and Eduard Petlenkov[b]

[a]Department of Electrical Power Engineering and Mechatronics, Tallinn University of Technology, Estonia

[b] Department of Computer Systems, Tallinn University of Technology, Estonia

Abstract

The study proposes and substantiates a set of updated active blended learning tools designed to attract and support the interest of power engineering students in creativity, innovation and sustainable development skills required by Industry 5.0, the latest initiative of the European Commission. An emphasis of the proposed approach is on the promotion of flexibility and adaptability, cooperation and leadership, literate written and oral communication, along with self-regulation and intercultural competence. A case study in training local and international mobility students at the Department of Electrical Power Engineering and Mechatronics reveals a number of important benefits of the method. At the same time, this paper demonstrates that students often have problems in implementing active blending in learning because of lacking the skills to wisely manage their educational process, as well as competently navigate among a variety of goals and actual conditions. Therefore, as a mandatory target of modern engineering education the paper defines assistance to students in balancing their ambitions with own capabilities, character traits, and real life constraints. Fortunately, these features can be taught within the proposed active blended learning methodology. It is expected that the study outcomes will be in demand by students, faculty and industry in the near future ahead of the big challenges facing Europe.

Keywords: sustainable power engineering; engineering education; active blended learning; Industry 5.0.

How to cite: Vodovozov,V.; Raud, Z. and Petlenkov, E. (2024) Active blended learning of industry 5.0-oriented sustainable power engineering specialists. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 719-725. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The latest Industry 5.0 initiative of the European Commission is directed to strengthening the influence and contribution of industry to society (Industry 5.0, 2023). Herewith, this initiative shifts the focus from economic growth to social value and from welfare to wellbeing. To accelerate the development of Industry 5.0, substantial changes in education are required to meet the needs of the novel workforce. This is reflected in significant modifications of the curricula and academic programs that should affect the current and future generations of professionals. In addition, a comprehensive update of the basic principles of education is coming in training specialists able to promptly understand the enhanced complexity of modern human-machine systems and make competent judgments (Renda et al., 2021; Adel, 2022).

Currently, the most promising educational technologies are associated with active learning, blended learning and their combination in the form of active blended learning (ABL) (Vodovozov et al., 2022). As noted in (Snape & Fox-Turnbull, 2011; Blair, 2012; Stehle & Peters-Burton, 2019), both active and blended learning approaches successfully help learners solve problems that have no obvious and ready-made solutions. In also helps them identify new challenges, make original decisions, and explore questions that are difficult to answer.

In this context, the purpose of the current study is to propose and substantiate a set of improved ABL tools designed to attract and support an interest of power engineering students in creativity, innovation and sustainable development skills required by the Industry 5.0 initiative. The emphasis is on building qualities such as flexibility and adaptability in problem solving, collaboration and leadership, effective oral and written communication, self-regulation, new media literacy, sociability and intercultural competence along with critical thinking. (Carpenter & Pease, 2013). It is expected that the proposed educational approach will be in need of learners, faculty and industry in the near future ahead of the big challenges facing Europe.

2. The method

This research was conducted at the Department of Power Engineering and Mechatronics in Tallinn University of Technology (TalTech) during four academic semesters, spring and autumn 2022 and spring and autumn 2023, at the bachelor's and master's levels. A total of 200 English-speaking Estonian and international mobility enrollees were invited to apply the ABL in either the compulsory courses of their Integrated Engineering and Electrical Power Engineering specialties or elective disciplines for other profiles. The students were diversified in terms of academic backgrounds, with 96 participants from the bachelor's degree program (48%) and 104 learners from the master's degree program (52%). As a whole, the students with multilateral prerequisites (electrical, mechanical, info-technological) and various

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

knowledge levels were joined in a unified educational environment. Such differences correspond to the needs of Industry 5.0, where multidisciplinary engineering teams are desirable to collaboratively solve complex industry and community problems.

The curriculum for all participants included weekly lectures, computer exercises every two weeks, laboratory works, and assessment. As a prerequisite for obtaining a final grade, students had to complete a prescribed number of mandatory computer tasks and laboratory works. Each student was asked to choose between traditional face-to-face learning with a summtive exam at the end and the ABL. In the latter case, most of the course content (with the exception of on-site supervised laboratory works) could be done by participants either in class or independently online.

Assessment principles are known as an important factor in the success of any educational methodology (Care et. al., 2016; Raud & Vodovozov, 2019). Instead of simply referring to software designed for online checking student progress, all assessment procedures have been rethought and redesigned with a focus on combining knowledge testing and creativity evolvement. Unlike the usual summative assessment-centric learning, a formative assessment system was applied for those who chose the ABL. This approach is based on bonuses accumulated during the semester as a reward for participation in multiple optional activities. A weighted sum of these bonuses was offered to students as their expected exam grade. Those who were not satisfied with it could choose a regular exam instead.

Lectures were broadcast weekly via the Internet from the auditorium, which students could voluntarily attend. Lecture recordings were regularly published. Along with them, slides of the lecture presentations and literature lists were posted, which participants could study on their own. To increase the lectures attractiveness and usefullness, they were accompanied by polls, and all students could take part in these events, thus receiving additional bonuses. Alongside the on-lecture polls, student's questions were encouraged and supported, and thus the tendency to ask questions became more attractive with each lecture.

To carry out formative assessment, each lecture was accompanied by randomly organized quizzes. Quizzing was arranged in such a way as to help students use their setbacks and errors for learning and progressing. Most of the quiz issues were usually associated with the current topic of the lecture in order to contribute to the study of lecture recordings, slides and literature. The remaining questions were aimed at testing knowledge of the fundamental laws of power engineering and sustainable development. Each test functioned during the lecture week. After the deadline, the results were published, the answers were evaluated, and correct solutions were archived so that students could study them afterwards.

Attendance at the computer exercises was also optional, and participants could decide for themselves whether to follow them online or be present on the spot. Thus, by using the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

manual to perform the exercises, students could independently complete their individual tasks or carry them out under the supervision of staff. Some of the exercises were compulsory, while others were optional, specifically intended to develop additional knowledge and improve academic performance.

During the semester, several time slots were booked for laboratory sessions. Again, some labs were mandatory whereas others were optional that, however, required some creativity but added bonuses to student grades.

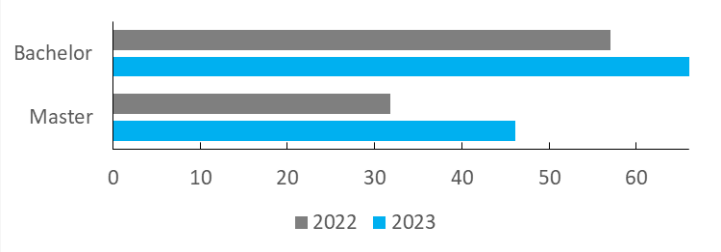
An IEEE international student workshop "Amazing Robotics" was organized for the learners as another optional ABL event. Preparing presentations and participation at the workshop required additional time and efforts but were also rewarded.

3. Results

To estimate the effectiveness of the ABL method, the university database of exam grades, feedbacks, comments of students and staff along with a repository of logs, activity reports, course participation lists, and statistics of the institutional learning management system was involved.

Figure 1 displays the tendency of growing students' interest in participating in optional ABL activities.

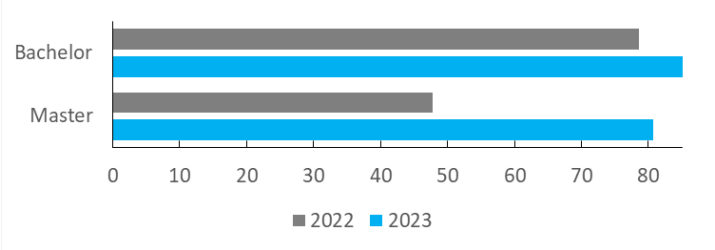
Fig. 1 – Percentage of students interested in ABL



Source: Own elaboration

Figure 2 reflects the growing student's interest in replacing summative exam with formative assessment.

Fig. 2 – Percentage of students participated in formative assessment

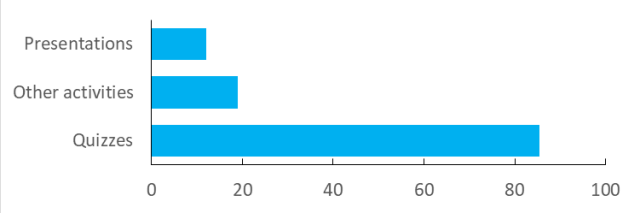


Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

The learners preferred summative assessment could study without options. Those who chose the ABL approach, participated on quizzes, presentations, and other activities, such as on-lecture polls, additional exercises, and elective labs. Figure 3 demonstrates the percentage of students who chose different optional activities.

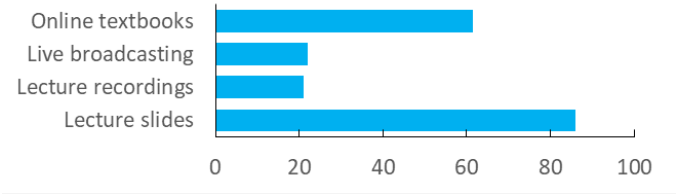
Fig. 3 – Percentage distribution of optional activities among ABL participants



Source: Own elaboration

On their way to increasing bonuses, the ABL participants used multiple information sources. Figure 4 specifies percent ratios of these sources.

Fig. 4 – Sources of information used by the ABL participants



Source: Own elaboration

4. Discussion

Above results reveal that, in general, most students were pleased with the ABL methodology, which use and implementation has a positive impact on the development of their future professional skills required by the Industry 5.0 paradigm. According to feedbacks, ABL is a suitable setting that helps students from different cultures to study successfully and provides good conditions for interaction between people of various backgrounds.

Students who have a choice between the traditional learning and the ABL format are increasingly choosing the ABL method every year. This confirms the validity of the statements found in (Erdem et. al., 2019; Strzelecki, 2023) that higher education should focus on active and blended approach, preferring it to content-oriented and final assessment learning. Many optional activities demonstrate student's research abilities known as an important component of creativity (Snape and Fox-Turnbull, 2011). In our case, students obtained the opportunity to exhibit their ideas through the internationally recognized IEEE vTools platform (IEEE, 2023), where communication and collaboration allow the participants to receive feedbacks from experts and share their expertise and knowledge.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

However, despite the many advantages of ABL, this study demonstrates that students often have problems in applying ABL due to some reasons. First, because of their inability to evaluate the correctness of data coming from the Internet, as they do not have enough skills for critical and competent assessment of what data are relevant and what should be discarded. Second, many of them cannot construct their own learning because information available through media tools is not always reliable and access to data requires information literacy (Erdem et. al., 2019; Stehle & Peters-Burton, 2019). Third, and most important, because of lacking the abilities to wisely manage their educational process, as well as competently navigate among a variety of goals and actual conditions. Therefore, assistance to students in balancing their ambitions with own capabilities, character traits, and real life constraints is to be defined as a mandatory target of modern engineering education along with helping them work in a technology-rich environment and navigate among the "waste" in every situation. Fortunately, these features can be taught within the proposed ABL methodology.

5. Conclusion

The learning and teaching organization discussed in this paper helps overcome several barriers in training the sustainable power engineering specialists. It is shown that the ABL approach makes students more independent and courageous, since everything they learn there, they learn on their own. The renewed methodology successfully attracts and supports the interest of entrants in creativity, innovation and other advanced skills.

This research presents the ABL as an effective method for power engineering students with different educational backgrounds and forms of study. As follows from the presented diagrams, the students who could choose between the traditional and the ABL formats, with each year more often select the latter approach. Activities such as poll-supported lectures, quizzes, creative exercises, team-oriented laboratory works, and student presentations confirm that the ABL is suitable for arousing curiosity and stimulating exciting learning about sustainable energy, demanded by the 5.0 industry. It is expected that the study outcomes will be in demand by students, faculty and industry in the near future ahead of the big challenges facing Europe.

Acknowledgement

This work was supported by the Estonian Research Council grant PRG658

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Adel, A. (2022). Future of industry 5.0 in society: Human-centric solutions, challenges and prospective research areas. *Journal of Cloud Computing: Advances, Systems and Applications*, 11:40. https://doi.org/10.1186/s13677-022-00314-5

Blair, N. (2012). Technology integration for the new 21st century learner. *Principal*, January/February, 8 – 13.

Care, E., Scoular, C. & Griffin, P. (2016). Assessment of collaborative problem solving in education environments. *Applied Measurement in Education*, 29(4), 250 – 264. https://doi.org/10.1080/08957347.2016.1209204

Carpenter, J. P. & Pease, J. S. (2013). Preparing students to take responsibility for learning: The role of non-curricular learning strategies. *Journal of Curriculum and Instruction*, 7(2), 38 – 55. https://doi.org/10.3776/joci.2013.v7n2p38-55

Erdem, C., Bağcı, H. & Koçyiğit, M. (2019). 21st Century Skills and Education, Cambridge Scholars Publishing, Newcastle: UK, 225 p.

IEEE MGA vTools. (2023). https://vtools.ieee.org/

Industry 5.0. (2023). European Commission. https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/industry-50_en.

Raud, Z. & Vodovozov, V. (2019). Advancements and restrictions of e-assessment in view of remote learning in engineering. *IEEE 60th International Scientific Conference on Power and Electrical Engineering of Riga Technical University* (*RTUCON*). Riga, Latvia, 1 – 6.

Renda, A., Schwaag Serger, S., Tataj, D. et al. (2021). Industry 5.0, a transformative vision for Europe – Governing systemic transformations towards a sustainable industry, European Commission, Directorate-General for Research and Innovation, Publications Office of the European Union. https://data.europa.eu/doi/10.2777/17322

Shear, L., Butler, D. & Leahy, M. (2023). Examining the artifacts of classroom practice: 21st century learning rubrics for teacher professional development. In: M. Koehler & P. Mishra (eds.), Proceedings of SITE-2011 – Society for Information Technology & Teacher Education International Conference, Nashville, Tennessee, USA, 1959 – 1963. https://www.learntechlib.org/primary/p/36588/

Snape, P. & Fox-Turnbull, W. (2011). Twenty-first century learning and technology education nexus. *Problems of Education in the 21st Century*, 34, 149 – 161.

Stehle, S. M. & Peters-Burton, E. E. (2019). Developing student 21st century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, 6:39. https://doi.org/10.1186/s40594-019-0192-1

Strzelecki, A. (2023). To use or not to use ChatGPT in higher education? A study of students' acceptance and use of technology. *Interactive Learning Environments*, 1 – 14. https://doi.org/10.1080/10494820.2023.2209881

Vodovozov, V., Raud, Z. & Petlenkov, E. (2022) Active blended learning engineering students: A case study. *Education Sciences*, 12(5): 344.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Exploring the Affordances of Blockchain Technology to Enable 5-R Permissions for Co-Creating OER

Bence Lukács[a]

[a]Institute of Applied Blockchain (IABC) Berlin, Germany

Abstract

This theoretical and conceptual paper discusses how blockchain technology can be leveraged to facilitate the 5-R permission for co-creating Open Educational Resources (OER). With the continued expansion of online and distance education over the last few years, the need for openly available teaching and learning materials only increased, but licensing issues, content availability and lack of incentives to adopt OER continue to hamper a true mass adoption. The accelerated growth of OER and the demand for transparency, traceability and trust in learning and teaching resources have brought blockchain technology to the forefront as a potential solution for addressing the challenges associated with intellectual property rights, content provenance and decentralized collaboration. This exploration presents the theoretical implications of blockchain's support for the 5-R, namely "retain" through immutable data storatge, "reuse" and "remix" by ensuring trust and tracebility of resource origins, "revise" by documenting content changes and "redistribute" through secure and verifiable transactions. This inquiry will provide a conceptual foundation for understanding how blockchain technology can offer an innovative and robust (infra-)structure to support and uphold the 5-R permissions.

Keywords: open educational resources; blockchain; openness; co-creation.

How to cite: Lukács, B. (2024) Exploring the Affordances of Blockchain Technology to Enable the 5-R Permissions for Co-Creating OER. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 726-734. https://doi.org/10.4995/SEED2024.2024.xxxxx

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Enabling universal access to education was entrenched as a human right in 1948 and by the 2020s supranational organisations, such as UNESCO (2017, 2019), further established the need for quality access to education in the Sustainable Development Goals (SDGs). In both instances the concept, idea and ethos behind Open Educational Resources (OER) is foundational. The accessibility and development of OER is being tackled either through policy on national or local levels or through various educational initiatives that try to combat specific issues, e.g. cost of books at the university level or a general access to a wide variety of educational materials during the pandemic teaching period. Unfortunately it has to be noted that despite the efforts of policymakers and dedicated individuals, a true mass adoption of OER has not been achieved yet. Simultaneously researchers are trying to understand all the potential barriers to adoption and thereby help develop action items for policy and suggestions for methodology to overcome these issues. Among the various reported barriers researchers have identified licensing issues, author acknowledgment and incentives as potential issues hindering further adoption (Guy et al., 2019; Amiel, 2013; Banzanto, 2012; Cox & Trotter, 2017; Luo et al., 2020).

This theoretical and conceptual paper aims to describe a potential technological remedy to these barriers while building on and incorporating the central framework behind the concept of OER, namely the 5-R permissions and activities (i.e. reuse, remix, retain, reivse and redistribute) formulated by David Wiley. First, the paper will present a brief overview of the history of openness, specifically singling out the developments from Open Access (OA) to Open Science (OS) and the definition of open content by David Wiley. All having the ultimate goal of promoting free access to science, knowledge and education. By building on the understanding of openness in regards to education as formulated in the Cape Town declaration, and with reference to the UNESCO Recommendation on OER, the paper will then connect with blockchain technology as a novel technological innovation in order to further implementation. As there are explicit mentions of the need for open technology and infrastructure for the use OER so it can unfold its full potential, a novel technological innovation becomes necessary (Open Society Foundation & Shuttleworth Foundation, 2008). It will be argued that the inherent functioning and affordances of blockchain technology can be matched onto the ideas and vision of open education communities and advocates and therefore potentially provide the necessary (infra-)structure to overcome the aforementioned barriers.

After a brief overview of the key and central aspects of this novel technology, the paper will present its main concept, namely applying the 5-R permissions of open content in the framework of the technology and examine examples of how open education and OER could make use of it. Finally, the paper will close by providing an outlook into future developments

BY-NC-SA 2024, Editorial Universitat Politècnica de València

while focusing on the interdisciplinary research desiderata necessary to develop further research.

2. Openness Declarations and Initiatives as Foundation

The concept of openness and enabling accessibility to scientific research and educational materials for more than academia and educational institutions arguably has a long tradition. But the drive to truly open up science and education has only recently been put into policy action items and discussed on national and international levels. One of the more important texts published was the Budapest Open Access Initiative in 2001 which set the foundation for future discussions and policies regarding the publishing of scientific research and articles (Open Society Foundation, 2001). The key aspect of the proposed concept and strategy was to make all research openly accessible, i.e. that researchers can access any published research without additional costs thereby aiming to change or reform the publication industry. The argument underlying these ideas was simple: by making research and scientific knowledge widely available among researchers it would eventually benefit the public, science itself, medicine and education.

Following the Budapest Initiative another important step in developing openness strategies was formulated in 2003. The Berlin Declaration on Open Access took up the general concept and idea proposed previously, but incorporated the internet as a vehicle for dissemination of scientific knowledge and to access the global scientific network (Max-Planck-Gesellschaft, 2003). Interestingly, the focus was also for the first time put on the digital format of scientific output and knowledge and pointed towards the question of author acknowledgment, appropriate licensing and how rights should be used and managed. Additionally, the focus of openness was extended towards more than accessing scientific literature. Instead the concept now also included a call for making data (e.g. meta data) and supplemental materials available too. But to be able to narrow the scope of this conceptual discussion, the focus shall now be pointed towards the educational area. The most recent iteration among the openness-related declarations was published in 2007 called the Cape Town Declaration (Open Society Foundation & Shuttleworth Foundation, 2008). It iterated upon the previously mentioned ideas and strategies, but specifically focused on the OER aspect of the openness framework. It continued to build on the idea that not only scientific literature should be made freely accessible and that scientific knowledge should be shared across the globe (thanks to networks based on the internet), but that educators, teachers and learners have to be called upon to actively participate in the creation of open education, which contain open educational practices, supporting open education policies and the use of OER. Most importantly, the need and necessity for open technologies as a potential driver is mentioned (e.g. collaboration, sharing, empowerment).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

These complementary initiatives can be understood as a framework and vision that covers academic research, educational materials and cultural data. While keeping this framework and vision in mind let us now turn our focus on the practical developments that happened concurrently to these declarations being published, namely the creation of open licensing of creative works and the definitory work done by David Wiley, who operationalised the concept of open content in the field of education (Wiley, 2007).

2.1 Open Content and Open Licensing for Education

Even before the aforementioned declarations were published, David Wiley proposed an Open Publication License in 1999, which can be understood as the inception of the idea and concept of making content freely available through proper licensing structures. More specifically, the Open Content project can be seen as the precursor for the development of OER as Wiley engaged himself in developing this concept of openness further through using Creative Commons licensing, eventually putting them to use for educational purposes.

Over the last few decades the Creative Commons licenses have become a major driver of open education and initiatives such as OER, but the initial idea of this concept is seldom discussed. During the initial struggles with operationalisation of openness and open content Wiley started conceptualising an explicit Open Education license, because he encountered various issues with the commonly used frameworks. Based on his work and experiences with this licensing structure, he first formulated the 4-R permissions as a guideline to understand and being able to use open content (Wiley, 2007). Some seven years after he introduced the 4-R into the discussion and after working within this framework the need arose to introduce the fifth permission into the framework, namely the "retain"-aspect thereby completing the 5-R permissions, which are still regarded as the foundation of the OER concept today (Wiley, 2014).

2.2 Barriers for opening up education

Unfortunately after many decades of concepts, ideas and development, with the term openness becoming more common in educational and academic circles and OER policies being developed and ratified nationally and locally, there seems to still exist structural barriers hindering mass adoption (Marín et al., 2022). Despite countries and supranational (political) organisations promoting policies and offering extensive guidance on enabling more open educators to make use of OER, public awareness could not be fully translated into action .

After the initial enthusiasm started dying down outside of the open education communities and advocates, researchers began to analyse, observe and study the impact and the actual operationalisation of the proposed principles and more specifically OER in the educational

BY-NC-SA 2024, Editorial Universitat Politècnica de València

landscape. In addition, updated strategy papers began to mention the need for innovative technological infrastructure to support the ease of use and further enable the 5-R permissions to come into action. One of the commons themes among the research findings, which in some parts have also been replicated already, pertain to the still ongoing unclear understanding and difficulty with licensing structures, as well as the Intellectual Property (IP) policies either nationally or internationally (Alkhasawneh, 2020; Nkwenti & Abeywardena, 2020; Kursun et al., 2014; Henderson & Ostashewski, 2018). Similarly, the incentive structure for producing openly licensed educational materials does not sustainably incline educators, teachers and learners to create material for the community (Marín et al., 2020; Mishra, 2017; Annand & Jensen, 2017).

3. Blockchain Technology and the 5-R Permissions

In order to make the conceptual connections with blockchain technology and its affordances in combination with the 5-R permissions in this chapter, it is necessary to give a concise, non-technical explanation of the key functional concepts. Firstly, blockchain as a technological concept functions based on the so called distributed ledger technology (DLT). In essence, this allows for a decentralised storage of information (i.e. data) on public ledgers, as the ledgers are connected as blocks by cryptographically secured hashes. These secure connections, effectively functioning as a peer to peer network, provide the security for individual pieces of information as well as the entire network. Because of the connection of these blocks it is virtually impossible to make changes in the information as the entire network either confirms the changes made to the network and/or carries a copy of the hashed information (Drescher, 2017). The second innovation often combined with blockchain technology are 'smart contracts', i.e. an automated program or transaction that is executed based on specified agreements (Fries & Baal, 2019). Let us now explore how this technological innovation could potentially operationalise the permissions for open content:

Retain (i.e. owning a copy of the resource): The ownership of the information (i.e. data) is one of the key pillars of blockchain technology. The decentralised aspect of the infrastructure enables individual empowerment and partaking in the up-keeping of the network, thereby securing oneself and the others.

Revise (i.e. modifying a copy of the resource): Based on the transparency and the chronological nature of the data storage, modification of materials is traceable, transparent and can provide a clear history of the revisions made. This helps with the tracking of contributions over any amount of time. While these revisions and modifications are transparently stored and timestamped, it provides a clear ownership record and enables anybody during later modification processes to track the original author and the original source of the material.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Thanks to this structure, it becomes possible to preserve the rights of each contributing author while also allowing legitimate adoptions.

Remix (i.e. combine existing resource with other resources): Although this aspect is mainly contingent on the technical infrastructure of the primary materials used, as the blockchain only offers storage and tracking capability, this permission can similarly be enhanced in combination with the other permissions. Firstly, by following the 5-R permission structure, it can be posited that material shall always be available thanks to the decentralised structure of the network, enabling continued access to material in order to use them in various formats. But secondly, the most interesting aspect in terms of innovation is the use of smart contracts, which can enhance the remix process through automated recognition of authorship when changes are made to the materials. Smart contract help facilitate the combination of different pieces of content by enforcing automated rules for attribution and usage, allowing the remix and combination of different works while also respecting the authorship and previously made adjustments and modifications to the material (such as the case for CC-BY Share-Alike license) (Ante, 2021).

Reuse (i.e. public use of the resource): As previously mentioned, the decentralised structure enables data availability in any circumstance and setting, providing insurance against potential restrictions by third parties, such as educational publishers or EdTech companies, who can take offline and change usage permissions as they wish. Additionally, the use of smart contracts can be made useful in this instance as well, as they would enable the automatised use and control of permissions for re-use by ensuring that the licensing agreement and usage terms would be followed. Without having to resort to manually approving or checking if the licensee re-used and re-mixed resources appropriately.

Redistribute (i.e. sharing resources with others): Some of the key aspects of the redistribution part have been covered in the previous permissions, e.g. data provenance as the (peer to peer) community upholds the functioning of the network, thereby taking back control from potential third parties who would usually store and control educational materials in their own repositories. But more importantly, when combining all the above mentioned permissions with the technology, the incentivisation of creating, sharing and remixing material could be viewed in an entirely new light, as the co-creation of educational materials can be appropriately renumerated through donations or public funding, while transparently being able to trace the travels of educational materials (from remix to remix). Finally, thanks to the unique affordances of this technology, the financial gain/model would stay wholly within the educational space and benefit every person who had a part in the creation or remix process of the educational material, again removing publishers and providers as the third party control mechanism. These strategies have to be conceptualised further and require more

BY-NC-SA 2024, Editorial Universitat Politècnica de València

theory work from the economics perspective, but nonetheless can offer a hope for all involved in the educational processes of creating, sharing and remix materials.

4. Discussion and Outlook

"An old tradition and a new technology have converged to make possible an unprecedented public good." (Open Society Foundation & Shuttleworth Foundation, 2001)

The aim of theoretical and conceptual research such as this is not to make normative judgements about the concept of openness, OER and new innovations such as DLT and blockchain, it much rather tries to view these areas from a new perspective and shine a light on the untapped and immense potential for both open education and technological innovations and development to inspire each other. It aims to initiate interdisciplinary research, especially between scientific field that maybe have less connection with each other, namely educational sciences and pedagogy with computer scientists and software developers. This research field in general is still wide open and in need of further depth, although more broad entry points are being discussed by UNESCO as well, see Education and Blockchain (Grech et al., 2022).

It can be argued that both OER, or open content generally, and blockchain technology simultaneously offer hope and innovation for relevant and serious issues within education and society at large, but have at this point not sustainably proven to be able to deliver on the promises and ideals. By combining two relatively unrelated fields of research, scientists and researchers can embark on improving definitions, developing understanding and iterating on theory and experiment with new ideas and concepts while continually researching potential use cases. While in 2002 when the Budapest Initiative was published, the old tradition was scientists sharing their work openly to enable free knowledge transfer and the internet was the new technology - now we can still use this philosophy as a guiding light: Teachers, learners and educators traditionally learn together, share their learning space for the sake of the community and learn from each other and the new technology is the blockchain. And with the help of it, educators, teachers and learners have the potential to fully embrace and live the 5-R permissions and move towards democratising educational processes.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Alkhasawneh, S. (2020). Perception of Academic Staff Toward Barriers, Incentives, and Benefits of the Open Educational Resources (OER) Network (SHMS) at Saudi Universities. Italian Journal of Sociology of Education, 12(Italian Journal of Sociology of Education 12/1), 211–225. https://ijse.padovauniversitypress.it/2020/1/12

Amiel, T. (2013). Identifying barriers to the remix of translated open educational resources. The International Review of Research in Open and Distributed Learning, 14(1), 126–144. https://doi.org/10.19173/irrodl.v14i1.1351

Annand, D., & Jensen, T. (2017). Incentivizing the Production and Use of Open Educational Resources in Higher Education Institutions. The International Review of Research in Open and Distributed Learning, 18(4). https://www.learntechlib.org/p/180470/

Ante, L. (2021). Smart contracts on the blockchain – A bibliometric analysis and review. Telematics and Informatics, 57, 101519. https://doi.org/10.1016/j.tele.2020.101519

Banzato, M. (2012). Barriers to teacher educators seeking, creating and sharing open educational resources: An empirical study of the use of OER in education in Italy. 2012 15th International Conference on Interactive Collaborative Learning (ICL), 1–6. https://doi.org/10.1109/ICL.2012.6402105

Cox, G., & Trotter, H. (2017). An OER framework, heuristic and lens: Tools for understanding lecturers' adoption of OER (2). 9(2), Article 2. https://doi.org/10.5944/openpraxis.9.2.571

Drescher, D. (2017). Blockchain Basics: A Non-Technical Introduction in 25 Steps. Apress. https://doi.org/10.1007/978-1-4842-2604-9

Fries, M., & Paal, B. P. (Eds.). (2019). Smart Contracts. Mohr Siebeck GmbH and Co. KG. http://www.jstor.org/stable/j.ctvn96h9r

Guy, J., McNally, M., Joseph, K., Sheppard, A., & Wakaruk, A. (2019). Strengths and Limitations of Open Educational Resources to Advance Copyright Literacy. Proceedings of the Annual Conference of CAIS / Actes Du Congrès Annuel de l'ACSI. https://doi.org/10.29173/cais1110

Grech, A., Balaji, V., & Miao, F. (2022). Education and Blockchain. Commonwealth of Learning (COL). http://hdl.handle.net/11599/4131

Henderson, S., & Ostashewski, N. (2018). Barriers, incentives, and benefits of the open educational resources (OER) movement: An exploration into instructor perspectives. First Monday. https://doi.org/10.5210/fm.v23i12.9172

Luo, T., Hostetler, K., Freeman, C., & Stefaniak, J. (2020). The power of open: Benefits, barriers, and strategies for integration of open educational resources. Open Learning: The Journal of Open, Distance and e-Learning, 35(2), 140–158. https://doi.org/10.1080/02680513.2019.1677222

Marín, V. I., Zawacki-Richter, O., Aydin, C. H., Bedenlier, S., Bond, M., Bozkurt, A., Conrad, D., Jung, I., Kondakci, Y., Prinsloo, P., Roberts, J., Veletsianos, G., Xiao, J., & Zhang, J. (2022). Faculty perceptions, awareness and use of open educational resources for teaching and learning in higher education: A cross-comparative analysis. Research and Practice in Technology Enhanced Learning, 17(1), 11. https://doi.org/10.1186/s41039-022-00185-z

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Max-Planck-Gesellschaft. (2003). Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities. https://openaccess.mpg.de/Berlin-Declaration

Mishra, S. (2017). Open educational resources: Removing barriers from within. Distance Education, 38(3), 369–380. https://doi.org/10.1080/01587919.2017.1369350

Nkwenti, M. N., & Abeywardena, I. S. (2020). OER mainstreaming in Cameroon: Perceptions and barriers. Open Praxis, 11(3), 289–302. https://doi.org/10.3316/informit.767553689389958

Open Society Foundation, & Shuttleworth Foundation. (2008, January 22). Cape Town Open Education Declaration. https://www.capetowndeclaration.org/

Open Society Institute. (2001). Budapest Open Access Initiative. https://www.budapestopenaccessinitiative.org/

UNESCO. (2017). 2nd World OER Congress: Ljubljana OER Action Plan. https://unesdoc.unesco.org/ark:/48223/pf0000260762

UNESCO. (2019). Recommendation on Open Educational Resources (OER). https://www.unesco.org/en/legal-affairs/recommendation-open-educational-resources-oer

Wiley, D. (n.d.). Defining the "Open" in Open Content and Open Educational Resources. Improving Learning. Retrieved January 25, 2024, from https://opencontent.org/definition

Wiley, D. (2007, August 8). Open Education License Draft. Improving Learning. https://opencontent.org/blog/archives/355

Wiley, D. (2014, March 5). The Access Compromise and the 5th R. Improving Learning. https://opencontent.org/blog/archives/3221

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Environmental Reports of Power Lines: promoting critical awareness about SDGs and professional ethics among engineering students.

Zaloa Aginako[a], Rafael Alberdi[a] and Teresa Guraya[b]

[a]Bilbao School of Engineering/Electrical Engineering Dept., University of the Basque Country (UPV/EHU), Spain

[b]Bilbao School of Engineering/Mining and Metallurgical Engineering and Materials Science Dept., University of the Basque Country (UPV/EHU), Spain

Abstract

This paper describes the activities carried out in the university classroom, in the electrical engineering degree, to develop, through critical thinking and with a perspective of professional ethics, awareness and knowledge about SDGs. The results obtained with a pre- and post- test are also presented to measure the intervention capacity to increase students' awareness and knowledge of professional ethics, SDGs (Sustainable Development Goals) and critical thinking. In this case, a SoTL (Scholarship of Teaching and Learning) approach has been followed, because it allows to advance systematically in knowledge and publication of results of educational researches in the academic field. The intervention was carried out in two groups with a total of 29 third-year students. The classroom activity consists of preparing an expert report after analysing the environmental and social implications that underlie the construction of a high voltage distribution line, based on critical analysis and in an PBL (Problem Based Learning) environment, by contrasting the two positions that are usually manifested in these cases: the need to develop the electrical network to provide quality electricity supply (SDG 9) and the opposition of environmental protection and neighbourhood groups (SDG 14 and 15). Studets perception test about their learning, show good result regarding SD and professional ethic knowledge and awareness abour SD, but not conclusive results about CT skills development and awareness about professional ethics.

Keywords: SDGs; critical thinking; engineering education; professional ethics; power lines.

How to cite: Aginako Z., Alberdi R. and Guraya T. (2024) Environmental Impact Report of Power Lines: promoting critical awareness about SDGs and professional ethics among engineering students. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. Pgs. 735-742. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The environmental and social impact in the construction of a high voltage power line is a complex problem that does not have an unique solution and that directly conditions the line's design. However, these social and environmental aspects are rarely analysed in depth within the electrical engineering degree's syllabus. Indeed, those questions are included anecdotally, or at most, slightly through the environmental report of the project, without making a critical analysis of all its implications in the environment and society, and without paying attention to the ethical role of the designer when carrying out this type of project. That is why this activity was designed, to go in deep into all the issues raised above. It should also be noted that the designed intervention has a sufficiently flexible framework for the inclusion of SDGs, and for the debate of the role of future engineers in the global action plan for sustainable development, as active agents of change to achieve the SDGs, as claimed by UNESCO (Rieckmann, 2017). In short, it is about carrying out an intervention based on the Problem Based Learning (PBL) methodology and critical thinking (CT) skills, to make students reflect on the impact of their future professional activity on Sustainable Development (SD). All this, through a critical thinking cycle designed from the work published by Bezanilla-Albisua *et al.* (2018).

Engineering accreditation agencies such as ABET, ENAE or IEA have recognized the importance of CT skills in the training of engineers. It was not the only reason for adopting a critical thinking cycle in our design, it was also chosen for its suitability with respect to the planned activity, which according to Ossa-Cornejo *et al.* (2018): "is a thinking process oriented toward understanding and solving problems, evaluating alternatives and making decisions. Critical thinking involves understanding, evaluating and solving, as well as self-evaluation, thinking about thinking (meta-thinking) and supporting conclusions in a well-founded way".

Beyond this specific intervention, the skill of critical thinking, once internalized, can be used in other similar engineering problems (complex, with open solution and linked to the SDGs). This gives to CT great added value as indicated by Paul and Elder (2003) in their definition: "critical thinking is that way of thinking – about any topic, content or problem – in which the thinker improves the quality of his or her thinking by taking hold of the inherent structures of the act of thinking and subjecting them to intellectual standards".

CT is also one of the basic competencies established by UNESCO to integrate the SDGs into curricula (Rieckmann, 2017). Other authors such as Sánchez-Carracedo *et al.* (2021), for the same objective of UNESCO in the field of engineering, advocate working with learning outcomes with an important presence of CT.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Regarding PBL, this methodology has been chosen due to the existing consensus on its suitability for working on complex engineering problems with open solutions (Yadav, *et al.* 2011; de Camargo Ribeiro, 2008; and Bhatti & McClellan 2011), as well as, to develop the CT. Regarding the latter idea, Oliveros *et al.* (2022) indicated that: "Learning based on the Problem Solving strategy (PBL) has shown the strengthening of CT, favoured by the activation of prior knowledge, reception of new concepts and the achievement of the ability to establish new research topics, it is based on the study of uncertainty scenarios where the solution is neither unique nor simple, which could promote certain generic competencies for comprehensive training and professional practice".

Quintero *et al.* (2017) describe an intervention to develop critical thinking in biomedical engineering through the application of PBL, and conclude that: "it promotes analysis, interpretation and evaluation skills" although it requires being used in more than one application cycle.

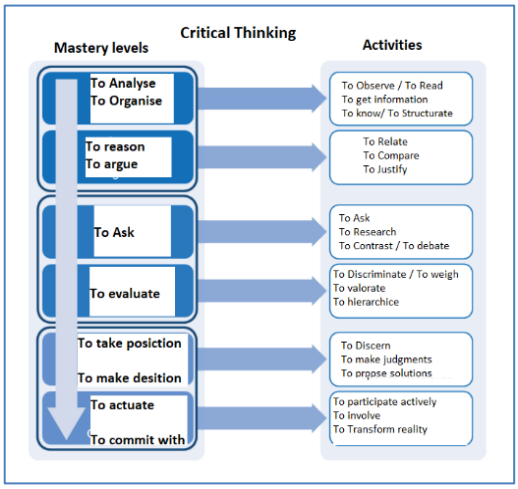
Furthermore, the literature review carried out by Ahern *et al.* (2019) on the presence of critical thinking in engineering education indicates that: "The most used teaching strategies to develop CT in engineering are: problem solving / problem-based learning, case studies and debates... with problem-based learning and project-based learning being the most used strategies".

For all these reasons, it was decided to use a critical thinking cycle in a PBL environment. To design the cycle, the stages of PBL published by Kolmos and De Graaff (2014) were compared with the activities and levels of CT described by Bezanilla-Albisua *et al.* (2018) (figure 1).

Fig. 1 – Comparison of the steps of Maastricht PBL model and the critical thinking

	PBL
1	Clarify concepts and terms not understood
2	Define the problem
3	Analyse the problem and offer tentative explanations
4	Make an inventory of the previous explanations
5	Formulate learning objectives
6	Seek additional information outside the group or individual study
7	Synthesis of the information and contrast or evaluate it with respect to the original problem. Reflection and consolidation of learning

Source: Kolmos and De Graff (2024)



Source: Bezanilla-Albisua *et al.* (2018)

Notice that the PBL procedure does not include the final phase of CT, which is to perform an action (actively participate, get involved or transform reality).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Finally, the elements of critical thinking were included in the sequenced PBL procedure, and a cycle of critical thinking adapted to the task was obtained.

2. Classroom Intervention

The main elements of the designed activity are described below.

2.1 PBL scenario

For the PBL, a *scenario* has been designed in which students must discuss the problem that exists between the need to build an infrastructure to improve the quality of the electricity supply and its environmental and social impact. To do this, they will analyse an actual environmental report of a distribution power line and discuss the points of view of the involved agents: distribution company, neighbours and environmental protectionists. Finally, the student must prepare an expert report according to the standard model of UNE 197001 (Spanish norm) that hypothetically would be presented to a judge. The court has commissioned the expert report *to assess whether the environmental report of the power line takes into account the needs of all the agents involved, and if it is compatible with SDGs 14, 15 and 9*. In the expert report, the students must discuss, argue and make judgments on the issues emerged in the analysis, taking into account CT skills and the ethical code of a professional engineering agency.

2.2 Tasks and timing

9 class hours (over 9 weeks) and 13.5 hours of non-face-to-face work are used to make a complete cycle of PBL about the problem in question using CT skills (figure 1). Each student will dedicate 22.5 hour to this activity (10 % of the credits of a 9 ECTS subject). The activities are carried out in groups of three students therefore cooperative learning techniques are also applied.

Student tasks include: learning about SDGs, CT and professional ethics; handling technical documentation in their professional field (environmental reports and expert standard reports); carrying out autonomous information searches; analysing technical documentation; discussing and building arguments; developing ideas, conclusions and their own judgments; and applying professional ethics to specific dilemmas.

In this way, they will acquire CT skills, transferable to other problems in the profession, and it is expected that there will be a change in attitude regarding professional ethics and the SDGs.

3. Research description

In this work, the underlying principle that has been followed is that: "Pedagogical procedures must be carefully planned, continuously examined and relate directly to the subject taught … Good teaching means that faculty, as scholars, are also learners" (Boyer, 1990, pp.22-23).

2024, Editorial Universitat Politècnica de València BY-NC-SA

Aditionally to materialize this principle, the SoTL (Scholarship of Teaching and Learning) approach was followed, according to which academics need to identify shared principles of good practice to improve systematically teaching-learning processes alongside research standards of the scientific community. According to Felten (2013) a quality SoTL must include the following principles: (1) inquiry into student learning, (2) grounded in context, (3) methodologically sound, (4) conducted in partnership with students, and (5) appropriately public. Therefore, the research design presented below aims to comply with all of this.

3.1 Research questions

The research is based on the hypothesis that students do not sufficiently know the foundations of critical thinking, professional ethics and SDGs within the framework of their future professional context. It is expected to know:

- After the intervention, are there changes regarding the students' knowledge about SDGs, professional ethics and critical thinking skills (information analysis, making judgments and inferring the consequences of adopted decisions)?
- After the intervention, does the students' awareness of the SDGs and professional ethics change?

To answer these questions, a test was developed, which was administered to students before and after the intervention. It is expected that the quantitative analysis of the responses and subsequent discussion will serve to answer the questions raised.

3.2 Sample

Students participate voluntarily and anonymously in the research, and are aware of all the terms of the research through informed consent that was redacted following the recommendations of the ethics committee of the UPV/EHU (López-Abadia, 2012). They know that they may withdraw from the research at any time. Although the intervention is part of a subject in which the students will be evaluated, the results of the pre- and post-test are not used to assess the subject. The potential number of students in the sample 29, but only 6 students (20 %) answered the pre and post test. They are third-year electrical engineering students with very few women in the cohort (10 %), so a study segmented by sex will not be done to guarantee anonymity. The students will also be part of the research as prescribed by the SoTL approach; their contribution will safeguard the anonymity of participants, and make a contribution to ethical aspects of the research.

3.3 The survey

It is an questionnaire with 25 closed questions designed ad hoc, based on the literature and adapted to the context of this specific intervention. It is expected to measure critical thinking

BY-NC-SA 2024, Editorial Universitat Politècnica de València

skills (items 16-25), knowledge about SDGs (items 7-9) and professional ethics (items 1-4), awareness of the SDGs (items 10-15) and professional ethics (items 5-6). It does not include questions to segment responses by gender or age.

Table 1 – Items

	Items
1	Do you know what the professional ethics of an engineer is?
2	Did you learn anything about professional ethics in any other subject in your career?
3	Do you know what corporate social responsibility is?
4a	An engineer can advise more than one party on the same project, whether or not there is a conflict of interest between them.
4b	Expert assistance in a trial may be provided by any expert engineer when requested directly by a judge.
4c	Engineers are obligated to practice engineering to promote the health, safety and well-being of the community and environment, although they must put the needs of their client first.
4d	Engineers must seek balance in their technical solutions, satisfying current needs without compromising those of future generations.
5	Do you think it is important to learn about professional ethics for your future job as an engineer?
6	As an employee, how important would it be to work for a company, which values its social and environmental responsibility?
7	Do you know the United Nations 2030 agenda? (Rate your knowledge from 1 to 5)
8	Do you know what the Sustainable Development Goals (SDGs) are? (Rate from 1 to 5)
9	Do you know which are the SDGs developed by electricity distribution companies?
10	As a citizen, by changing certain attitudes/customs, I will be able to contribute to the SDGs.
11	In my work as an engineer, I will be able to contribute to the SDGs by providing technical solutions to problems that arise with climate change.
12	In my work as an engineer, I will be able to contribute to the SDGs by applying environmental legislation.
13	In my work as an engineer, I will be able to contribute to the SDGs by applying hygiene and safety legislation at work.
14	In my work as an engineer, I will be able to contribute to the SDGs by carrying out renewable energy and energy efficiency projects.
15	Have you considered the idea of doing a final degree project that contributes to the SDGs at university?
16	I panic when I have to solve very complex problems, because I don't have a method to deal with them.
17	I prefer to apply known reasoning than risk trying something new.
18	I can explain in my own words what I just read
19	I can make comparisons between different solutions to a problem.
20	I use common sense when judging the relevance of information
21	I prefer evidence to my personal ideas.
22	I express novel alternatives despite the reactions they may generate.
23	I know how to distinguish between real facts and prejudices.
24	I can make an assessment of a problem even if I don't have all the information
25	Despite the arguments against, I hold firm to my beliefs.

Source of items 16 to 25 adapted from Quintero *et al.* (2017)

3.4 Survey administration

The questionnaire will be completed at the beginning and at the end of the intervention using a GoogleForm®, so that the anonymity of the participants is guaranteed. The participation codes will be managed and guarded by one student, and the researchers will not have access to them. Students will access the GoogleForm® through a link available via the university's virtual classroom. Explanations of the research to students, administration of the survey, and

 BY-NC-SA

all events related to the research will be conducted by a researcher who has no academic relationship with the students.

3.5 Data analysis, discussion and conclusions

A quantitative aggregated data analysis was carried out using analytical statistics, with the IBM SPSS program, the answer rate has been very low (6 students of 29), due to the low responses rate only a descriptive statistical analysis was conducted.

Most relevant results indicate that the activity improves the knowledge about SD between 40 and 100%, highlights item 8 (M_{pre}= 2,3 SD_{pre}= 1; M_{post}= 4, SD_{post}=0), it also improves knowledge about professional etics (item 1, M_{pre}= 1,8 SD_{pre}= 0,4; M_{post}= 2,7 SD_{post}= 0,5). Awareness about professional ethics does not improve, nevertherless, the awareness about SD improves up to 53 % (item 13). The results respect to CT are irregular. The results indicate that the designed activities promote learning of environmental and ethical issues, but are not sufficient to improve CT skills, perhaps longer actions along courses are needed. Finally, the little participation of students indicate that the 4th principe of SoTL approach was not satisfied, thus, the research design should be rewiev for other editions or activities, to involve students more.

Acknowledgements

The intervention and subsequent research described here (project number iKDi^3 23-14) was carried out and was financed, within the fourth educational innovation project program (iKDi^3 laborategia) of the vice-chancellor's office for undergraduate studies and teaching innovation at the University of the Basque Country.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Reference

Ahern, A., Dominguez, C., McNally, C., O'Sullivan, J. J., & Pedrosa, D. (2019). A literature review of critical thinking in engineering education. *Studies in Higher Education*, 44(5), 816-828. https://doi.org/10.1080/03075079.2019.1586325

Bhatti, P. T., & McClellan, J. H. (2011). A cochlear implant signal processing lab: Exploration of a problem-based learning exercise. *IEEE Transactions on Education*, 54(4), 628-636. doi: 10.1109/TE.2010.2103317.

Bezanilla-Albisua, M. J., Poblete-Ruiz, M., Fernández-Nogueira, D., Arranz-Turnes, S., & Campo-Carrasco, L. (2018). El pensamiento crítico desde la perspectiva de los docentes universitarios. *Estudios pedagógicos (Valdivia),* 44(1), 89-113.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Boyer, E. (1990). Scholarship reconsidered: priorities of the professoriate. New York: The Carnegie Foundation for the Advancement of Teaching/Jossey-Bass.

De Camargo Ribeiro, L. R. (2008). Electrical engineering students evaluate problem-based learning (PBL). *International Journal of Electrical Engineering Education*, 45(2), 152-161. https://doi.org/10.7227/IJEEE.45.2.7

Felten, P. (2013). Principles of Good Practice in SoTL. *Teaching & Learning Inquiry*, 1(1), 121-125. https://doi.org/10.20343/teachlearninqu.1.1.121

Kolmos, A., & De Graaff, E. (2014). Problem-based and project-based learning in engineering education: Merging models. In Cambridge handbook of engineering education research (pp. 141-161). Cambridge University Press.

López-Abadia, I. (2012). Estudiantes de la UPV/EHU como sujetos de investigación. Cuadernos CEID Vicerrectorado de Investigación. Bilbao: Servicio editorial UPV/EHU. Retrieved from: https://www.ehu.eus/documents/d/ceid/08_estudiantesinvestigac

Oliveros, J. A. C., Borges, C. G. R., Rodríguez, J. A. P., & Zambrano, X. H. V. (2022). Desarrollo del pensamiento crítico: Metodología para fomentar el aprendizaje en ingeniería. *Revista de ciencias sociales*, 28(4), 512-530. Retrieved from: https://produccioncientificaluz.org/index.php/rcs/index

Ossa-Cornejo, C., Palma-Luengo, M., LagosSan Martín, N., & Díaz-Larenas, C. (2018). Critical and scientific thinking assessment in preservice teachers at a Chilean University. *Revista Electrónica Educare*, 22(2), 204-221

Paul, R., & Elder, L. (2003). La mini-guía para el pensamiento crítico. Conceptos y herramientas. Dillon Beach, California: Fundación para el Pensamiento Crítico. Retrieved from: https://www.criticalthinking.org/resources/PDF/SP-ConceptsandTools.pdf

Quintero, V. L., Palet, D., Avila, J. E., Olivares, D., & Olivares, S. L. (2017). Desarrollo del pensamiento crítico mediante la aplicación del Aprendizaje Basado en Problemas. *Psicología Escolar e Educacional*, 21, 65-77. https://doi.org/10.1590/2175-3539201702111072

Rieckmann, M. (2017). Education for Sustainable Development Goals: learning objectives. UNESCO Publishing. Retrieved from: https://unesdoc.unesco.org/ark:/48223/pf0000247444

Sánchez-Carracedo, F., Segalas, J., Bueno, G., Busquets, P., Climent, J., Galofré, V. G., ... & Vidal, E. (2021). Tools for Embedding and Assessing Sustainable Development Goals in Engineering Education. *Sustainability*, 13(21), 12154. https://doi.org/10.3390/su132112154

Yadav, A., Subedi, D., Lundeberg, M. A., & Bunting, C. F. (2011). Problem-based learning: Influence on students' learning in an electrical engineering course. *Journal of Engineering Education*, 100(2), 253-280. https://doi.org/10.1002/j.2168-9830.2011.tb00013.x

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Renewable Technologies and Active Learning: Boosting Engineering Education through Student Research Groups

Luis David Sánchez Diana [a], María Dolores Reyes Tolosa [a] and Yolanda E-Martín [b]

[a] Engineering , Florida Universitària, Spain

[b] TICs and video game, Florida Universitària, Spain

Abstract

This paper addresses the increasing demand for graduates with both technical expertise and well-developed soft skills in today's competitive job market. Responding to this demand, higher education has witnessed a notable shift towards innovative learning methodologies. The formation of student-led research groups is an educational methodology that is not often exploited, but which can have a great impact facilitating the application of theoretical concepts within their disciplines. Particularly beneficial in engineering programs, this methodology addresses the longstanding challenge of translating theory into practical application. We explore the creation of multidisciplinary research groups, emphasizing their suitability for engineering disciplines and their adaptability to diverse topics, with a focus on sustainable technology projects aligned with UN Sustainable Development Goals (SDGs).

At Florida Universitaria, the establishment of the Energy Student research group exemplifies this approach, concentrating on renewable energy projects. This article delves into the ongoing wind technology project within this group, highlighting practical application, technical skill development, and soft skills acquisition. The proposed teaching-learning methodology proves effective in achieving project goals, aligning with the multidisciplinary nature of the project and the students involved. The results underscore the success of this approach in merging theoretical learning with practical application while actively contributing to the SDGs.

Keywords: learning methodology; research; renewable technologies; soft skills

How to cite: Sánchez Diana, L.D. ; Reyes Tolosa, M. D. and E-Martín, Y. (2024) Renewable technologies and active learning: boosting engineering education through student research groups. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 743-750. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Currently, companies demand graduates not only with the technical knowledge required in their specialization but also with highly developed soft skills. Consequently, there has been a clear trend in recent years in higher education towards adopting new learning methodologies, such as project-based learning. However, an underutilized teaching approach involves creating student-led research groups to develop competencies and apply academic content studied in degree programs [1]. This methodology is applicable to almost any degree in any field but becomes particularly suitable for engineering degrees. In these programs, achieving practical application of theoretical content has always been a challenging task and a common demand from students.

In this context, the creation of research groups allowing students to apply their knowledge while developing new technical skills and soft skills is especially relevant and well-regarded. This is not only beneficial for students who perceive personal growth but also for companies that value the profile of these graduates for their workforce integration [2]. Furthermore, given the multidisciplinary nature of engineering, it is possible to organize research groups around any topic, with a focus on the development or implementation of sustainable technologies for electricity generation being particularly useful and versatile. This thematic approach allows for the application of degree content, soft skill development, and direct action toward achieving the UN Sustainable Development Goals.

Considering the aforementioned, at Florida Universitaria, a new research group named "Energy Student" has been formed, comprised of students from different degrees such as Industrial electronic and automatic engineering and Mechanical engineering, focusing on the development of projects based on renewable technologies. Currently, the group is working on various lines such as biomass, photovoltaics and hydraulics. However, this article concentrates on describing the ongoing work centered on wind technology. Specifically, young researchers are engaged in characterizing and assembling a wind system for electricity generation, incorporating not only the energy generation system but also the measurement and communication system for monitoring and analyzing the entire system.

Thus, thanks to the proposed teaching-learning methodology and considering both the diversity of tasks to be performed and the multidisciplinary nature of the students, the project has successfully achieved its initial objectives of practically applying theoretical content from both degree programs while developing technical and soft skills [3]and actively contributing to the achievement of the Sustainable Development Goals [4].

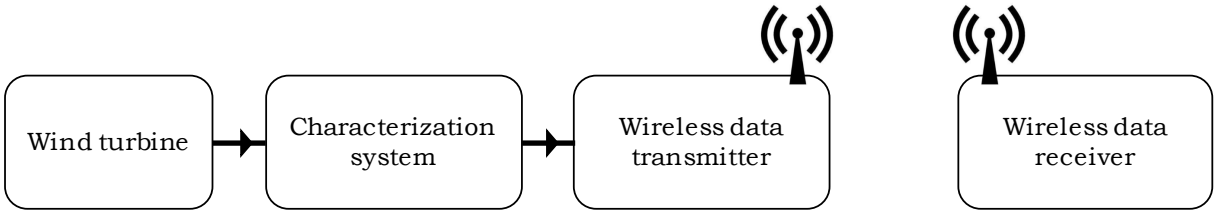
2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. Methodology

The Energy Student research group is composed of 16 students from various courses in mechanical and electronic engineering degrees. These students are distributed across different research lines, including biomass, photovoltaics, hydraulics, and wind technology. The criteria for forming the groups have been diverse, but it is noteworthy that they have been structured so that each group includes a senior student serving as a leader and guide for the younger members. Additionally, the groups have been configured to have members from both degree programs. This approach achieves several objectives, such as fostering the development of competencies (leadership, teamwork, critical thinking, etc.) and encouraging students to complement each other given their diverse backgrounds [5,6].

In the case of the wind technology group, the team consists of 6 young researchers, and the goal of their project is to implement an electricity generation system using a commercial wind turbine. This system is primarily outlined in Figure 1, where it can be observed that, in addition to the generation system, the project also includes the development of a measurement system and a communication system based on LORA technology to wirelessly transmit energy generation data to a receiver to store and analyze the data.

Fig. 1 – Scheme of the energy generation system, including the characterization module and the data transmission modules.



Source: Own elaboration

Through this project, the participating researchers aim to simultaneously attain academic, technical, and personal objectives. This involves applying theoretical knowledge in areas such as electronics, mechanics, and automation—spanning electric machines, power and consumer electronics, wireless communications, microcontroller programming, mechanical design, stress analysis, among other domains. Additionally, the project emphasizes the acquisition of essential competencies encompassing leadership, adaptability, teamwork, project management, and the proficient search and synthesis of information. Finally, the researchers are also actively engaged in advancing the Sustainable Development Goals, specifically targeting Affordable and Clean Energy (SDG 7), Industry, Innovation, and Infrastructure (SDG 9), Climate Action (SDG 13), and Partnerships for the Goals (SDG 17) [7].

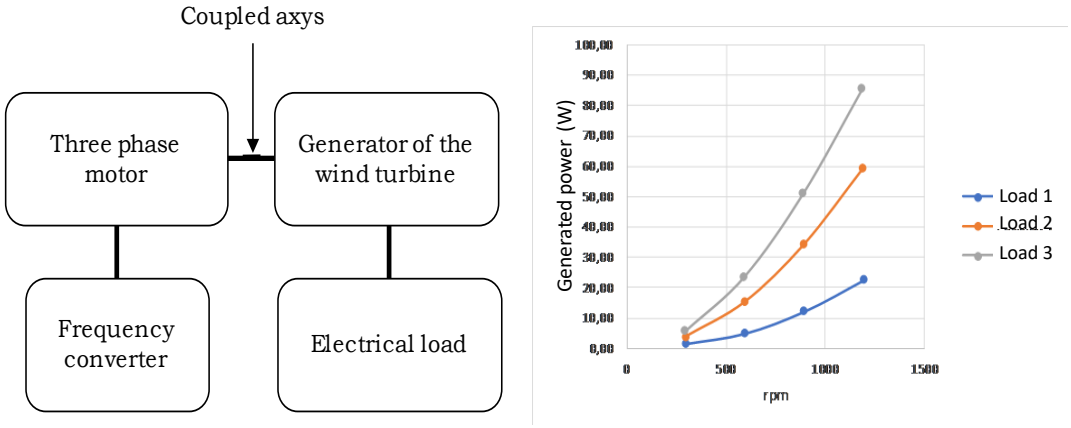
BY-NC-SA 2024, Editorial Universitat Politècnica de València

2.1 Experimental characterization of the commercial wind turbine.

For the wind turbine, two different models have been selected, both with the same power but one multidirectional with output in direct current and the other unidirectional with output in three-phase alternating current. The primary motivation behind selecting two different types of wind turbines is to enable the possibility of conducting various analyses and comparisons between them, allowing researchers to delve into the understanding of wind turbines with the future perspective of designing and manufacturing their own models. The characterization of the wind turbines involves obtaining their power curves in relation to the revolutions per minute of their axis for different loads. This characterization determines the device's capability to generate energy under different operating modes.

To facilitate comparisons between the different wind turbines, the researchers have developed the setup described in Figure 2.

Fig. 2 – Assembly for the generator characterization and characteristic curves of the wind turbine as a function of rotational speed and load.



Source: Own elaboration

The setup consists of a frequency converter, a motor, the generator, a variable load, a digital tachometer, and the relevant electrical protections. The frequency converter enables the generation of a three-phase power signal from the standard single-phase connection to power the three-phase motor. Additionally, it allows for the modification of the frequency of the motor's power signal, thereby controlling its rotational speed. On the other hand, the motor's shaft is coupled to the shaft of the wind turbine intended for characterization. By controlling the motor's rotational speed through the frequency converter, the rotational speed of the generator's shaft is effectively controlled. In this manner, the power generated by the generator can be measured in the load connected to its output, and it can be correlated with both the load itself and the rotational speed of the generator, thanks to the tachometer readings. Specifically, as shown in Figure 2, the voltage, current, and power generated at the

2024, Editorial Universitat Politècnica de València BY-NC-SA

output of the multidirectional generator have been determined for three different load levels and for rotational speeds of the wind turbine's shaft ranging from 0 to 1300 rpm.

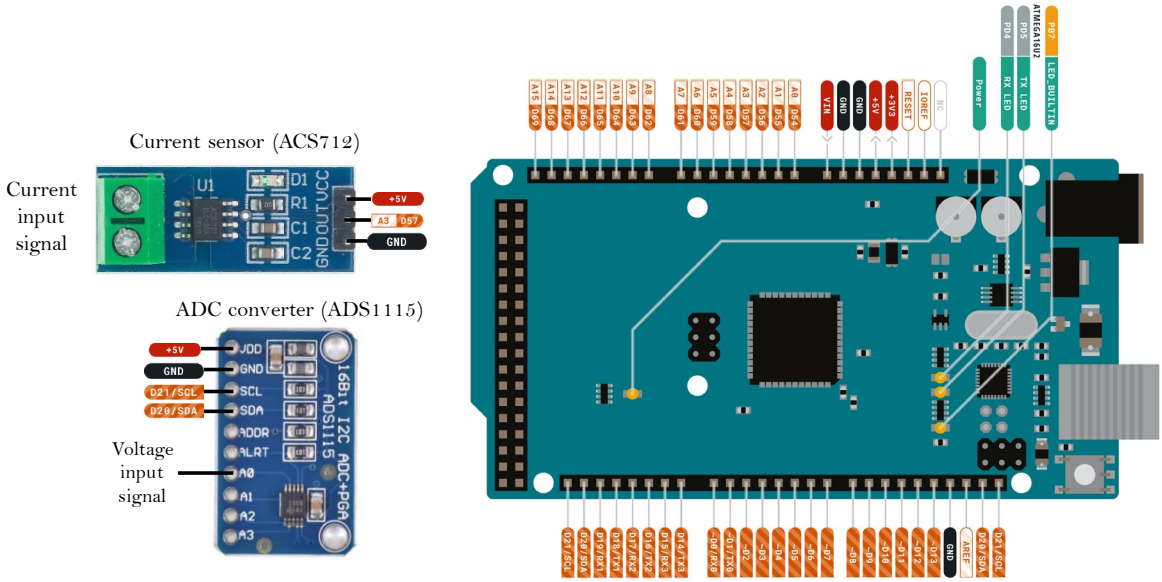
This way, it has been possible to determine the generator's response based on the load and rotational speed. The same analysis will be carried out with the unidirectional wind turbine, allowing researchers to make comparisons between both models and draw relevant conclusions from the analysis.

Finally, it is worth highlighting the richness of this activity for the researchers' development. Thanks to their participation in this part of the project, researchers have been able to deepen their understanding of theoretical concepts related to electromagnetic induction, reversibility of electric machines, and aerodynamics. Moreover, they have developed relevant technical skills such as programming frequency converters and applying a methodology for obtaining, representing, and analyzing data derived from experimental characterization.

2.2 Development of a portable experimental characterization system.

In this section of the project, a portable electronic device capable of measuring voltage, current and power for any electrical power generation system has been implemented by the researchers. The concept behind the device is that it can be used with a wide range of electric generators and, being portable, can be transported to any location where the analysis of a generator's operation is needed. In the project's context, the system is intended for measurements on the multidirectional wind turbine. The electrical schematic of the implemented system is depicted in Figure 4.

Fig. 3 – Scheme of the portable electronic system for generator characterization.



Source: www.arduino.cc

BY-NC-SA 2024, Editorial Universitat Politècnica de València

In Figure 3, it can be observed that the system is based on an Arduino Mega board that processes the voltage and current measurements obtained from the corresponding sensors. Additionally, it incorporates an LCD screen to provide a basic communication interface with the user, allowing for the input or selection of commands and displaying results.

Thus, when the generator injects energy into the load, the system can monitor the voltage and current and interpolate the power. Moreover, the system includes the ability to program a certain number of measurements and store the data on an SD card. In the next version of the device, it will be possible to send this data to a receiving module for dumping onto a server.

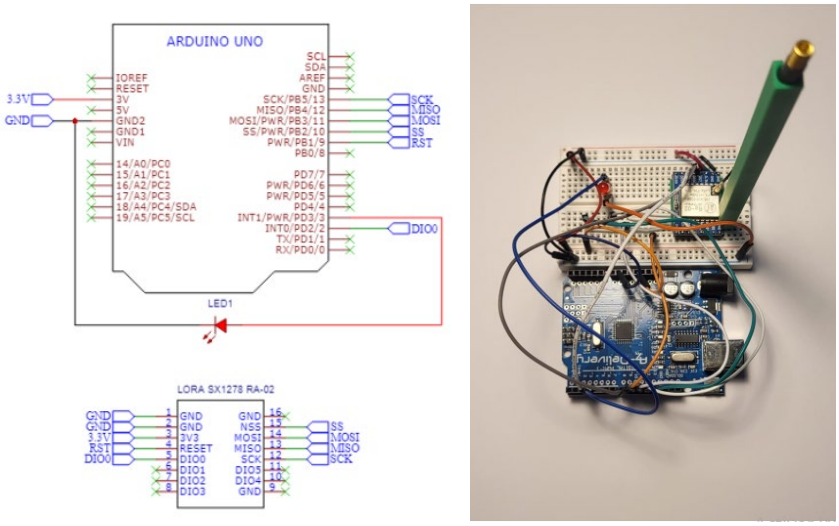
Regarding this activity, it is noteworthy that the researchers have deepened their knowledge in Python programming, Arduino, 3D printing, power electronics, and the conversions between analog and digital signals, and vice versa.

2.3 Development of a wireless information transmission system using LoRa technology.

Finally, the last stage of the system involves the implementation of a wireless communication system based on LoRa technology. LoRa, which stands for Long Range, is a low-power, wide-area networking protocol designed for long-range communication with minimal energy consumption. The use of LoRa ensures a robust and long-range wireless link, particularly suitable for applications where low power consumption and extended communication range are crucial. In this project, LoRa technology facilitates the transmission of data wirelessly between components, enabling efficient and reliable communication between the characterization system that measures the wind turbine generation parameters and the data acquisition system. In Figure 4, the main schematic of the transmitter and receiver modules can be observed. Both modules use Arduino UNO boards, LORA SX1278 modules and highly optimized antennas for wireless data communication. Through the completion of this project module, the researchers have been able to strengthen their knowledge regarding wireless communication protocols.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 4– Scheme of the wireless information transmission system using LoRa.



Source: Own elaboration

3. Conclusions

Through this project, the significant value that the formation of multidisciplinary research groups can bring to the training and development of engineering students has become evident. By forming diverse teams and undertaking various tasks, students have not only found a practical application for the theoretical knowledge acquired during their university studies but have also perceived personal competency development that prepares them to be highly qualified professionals. Moreover, given the wide range of research areas around which research groups can be configured, this methodology is easily applicable to any university degree, being particularly straightforward and beneficial in the field of engineering if the research lines focus on sustainability and renewable energies.

Acknowledgements

To Florida Universitària for their support in the development of new teaching and learning methods based on high-quality scientific research and commitment to the Sustainable Development Goals (SDGs).

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Segrera, F. L. (2012). La Segunda Conferencia Mundial de Educación Superior (UnEsco, 2009) y la visión del concepto de acreditación en las Conferencias de UNESCO (1998-2009). Avaliação, 17(3), 619-636. https://doi.org/10.1590/s1414-40772012000300004

Wagner, T., & Compton, R. A. (2012). Creating Innovators: the making of young people who will change the world. Choice Reviews Online, 50(01), 50-0425. https://doi.org/10.5860/choice.50-0425

Paul, R., & Elder, L. (2006). Critical thinking: The nature of critical and creative thought. Journal of Developmental Education, 30(2), 2-7.

Davis, M. (1991). Thinking like an engineer: Studies in the ethics of a profession. Oxford University Press.

Vives, A. Q., Garnes, M. P., & Tolosa, M. D. R. (2022). Evaluación de competencias transversales a través del aprendizaje basado en retos. International Journal of Human Sciences Research, 2(37), 2-10. https://doi.org/10.22533/at.ed.5582372228112

Santateresa-Bernat. P, Reyes Tolosa, M.D., Climent Ferrer, J. (2023). Analysis of creativity and innovation between higher studies in scientific-technical areas and social-humanist area. INNTED23

Atwater, L., & Yammarino, F. J. (1997). Self–other rating agreement: A review and model. Research in Personnel and Human Resources Management, 15, 121-174.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Scrollytelling as a Strategy for Socio-Environmental Engagement: A Digital Citizen Science Narrative Approach

Jorge Sanabria-Z[a, b], Inna Artemova[c], Gabriel Félix-Mendívil[b] and Pamela Olivo[a]

[a]Institute for the Future of Education, Tecnologico de Monterrey, Mexico
[b]School of Architecture, Art and Design (EAAD), Tecnologico de Monterrey, Mexico
[c]Centro Universitario GDL, Universidad de Guadalajara, Mexico

Abstract

The popularity of citizen science projects is widespread, particularly those related to socio-environmental issues. However, its dissemination through traditional science communication channels such as scientific journals lack the ability to reach and engage young audiences. In the context of higher education, a didactic pilot activity was implemented in which students from various disciplines participated in a five-week analysis of citizen science projects. The main objective was to design a digital interactive narrative that not only informed about the project, but also made it accessible and attractive to a young audience through *scrollytelling* (scrolling + storytelling), a multimedia interactive vertical digital storytelling technique. The Design Process and Practice methodology was adopted including phases of research, analysis, design and development of interactive digital content. Literature related to the public communication of science and the educational use of digital narratives was reviewed to identify effective outreach strategies. The main findings revealed that *scrollytelling* development facilitates a deeper understanding of the socio-environmental aspects addressed by citizen science projects, while promoting engagement and interaction of young audiences. This didactic approach proves to be an innovative strategy in higher education for teaching science and sustainability, providing students with practical tools for effective communication of science projects to society.

Keywords: Science Communication; Citizen Science; Engagement; Educational innovation; Higher education.

How to cite: Sanabria-Z, J.; Artemova, I.; Félix-Mendívil, G. and Olivo, P. (2024) Scrollytelling as a strategy for socio-environmental engagement: a digital citizen science narrative approach. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 751-758. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In today's world characterised by unprecedented global challenges such as climate change, biodiversity loss and the energy crisis, public communication of science and education to achieve sustainable development goals emerge as fundamental pillars for building resilient and sustainable societies. Effective science communication not only plays a crucial role in democratising scientific knowledge, enabling different sectors of society to understand and engage with scientific advances and challenges, but also fosters a culture of informed and critical decision-making on environmental issues (Burns et al., 2003; Nisbet & Scheufele, 2009). On the other hand, education for sustainable development goals is presented as an essential strategy to equip future generations with the knowledge, skills and values needed to address and solve problems from a sustainable perspective, promoting the efficient use of resources and the adoption of renewable energy sources (Rieckmann, 2017; Wiek et al., 2011). In this context, the integration of public communication of science and the sustainability perspective within educational programmes becomes an innovative approach that not only enhances young people's understanding and appreciation of science, but also catalyses change towards more sustainable and responsible behaviour in the face of contemporary environmental challenges.

Digital storytelling is an innovative communication tool that has significant potential for the dissemination of citizen science projects by combining visual, textual and interactive elements to tell stories in a more immersive and accessible way. This allows complex concepts to be broken down and scientific data to be presented in a way that captures the audience's attention and facilitates understanding and retention. Among the digital storytelling realm of tools and techniques, *scrollytelling* (scrolling + storytelling) emerges as a technique that leverages vertical scrolling on digital devices to progressively reveal information, graphics and animations, creating a dynamic narrative experience that can be adapted to different audiences and educational contexts. This form of communication has proven effective in increasing audience engagement and promoting greater interaction and reflection on the topics covered, which is essential to foster active and conscious participation in citizen science projects (Krauss et al., 2022; Kelly, 2014).

The main objective of this scientific article is to explore the use of *scrollytelling* as an innovative tool for the teaching and dissemination of citizen science projects that address complex socio-environmental problems. It seeks to evaluate how this digital storytelling technique can improve young people's understanding and engagement with these issues by involving them in the creation of interactive and engaging content. In addition, it aims to identify effective strategies for integrating *scrollytelling* into higher education contexts, to provide students with practical tools that foster effective science communication and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

contribute to greater environmental awareness and action through the recognition and dissemination of related citizen science projects.

2. Theoretical framework

Public communication of science plays a crucial role in sustainability education, serving as a bridge between scientific research and public understanding of environmental challenges. The literature on this topic suggests that effective communication can increase awareness and knowledge about sustainability issues, encouraging individuals and communities to adopt more sustainable practices (Nisbet, 2009; Khatibi et al., 2021). In this context, sustainability education benefits from communication strategies that not only convey information, but also foster critical thinking and students' ability to evaluate and act on complex environmental problems (Moser, 2014; Stevenson, 2022).

Studies highlight the importance of using digital narratives and media to make science accessible and attractive to young audiences, arguing that emotional and cognitive engagement with science content can drive significant change towards more sustainable behaviours (Dahlstrom, 2014; Bilandzić et al., 2020; Kumpu, 2022). Therefore, the integration of public communication of science in educational programmes emerges as a key strategy to prepare students to face the sustainability challenges of the 21st century, equipping them with the necessary knowledge and skills.

In the field of education, the use of digital narratives, such as *scrollytelling*, has gained ground as an effective means to improve learning and information retention among students. Previous studies have shown that these digital tools, by combining visual, textual and auditory elements, can facilitate understanding of complex concepts and foster greater student engagement and motivation (Dancsa et al., 2023; Haleem et al., 2022). Digital storytelling stands out for its ability to guide users through a story in an interactive way, allowing for deeper immersion in the content presented. Several studies have explored how it can be applied in educational contexts to tell scientific or social stories in a more engaging way (Robin, 2016; Alexander, 2017; Anand, 2023; Parola et al., 2022). This background underlines the relevance of integrating digital storytelling and *scrollytelling* into education, highlighting its potential to transform it into a more dynamic and participatory process.

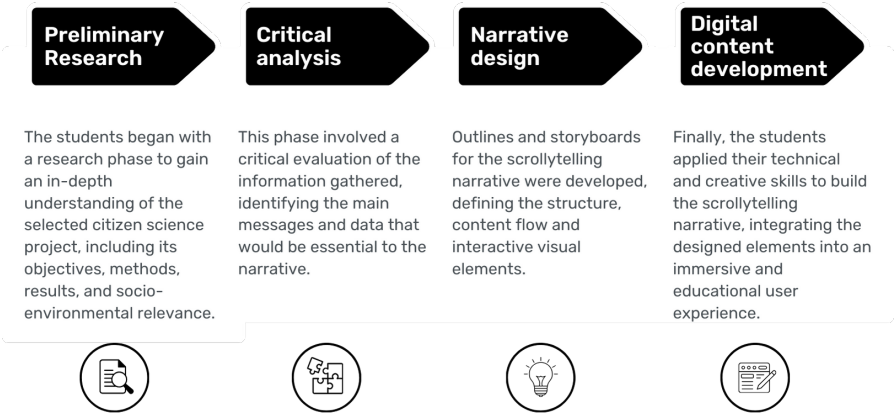
3. Methodology

A 5-week extracurricular pilot course was conducted where 17 higher education students enrolled voluntarily. All sessions were carried on online in a university platform. Their fields of study included finances, chemistry, and marketing, but most of them belonged to the field of "Creative Studies", such as industrial design and digital art majors. In the first phase, a selection of citizen science socio-environmental projects to be analysed by students was carried out. It was based on several criteria, including their relevance to addressing significant

BY-NC-SA 2024, Editorial Universitat Politècnica de València

socio-environmental problems, the availability of data and materials that could be effectively communicated through *scrollytelling*, and their potential to generate interest and engagement among young audiences. Each student was assigned a different citizen science project. Subsequently, didactic activities were implemented according to the four stages described in Figure 1. There were fifteen resulting presentations, as two of the participants worked together and one of the students did not deliver the requested activity.

Fig. 1 – Implementation stages of the *scrollytelling* proposal



Source: created by author

For the design and development of the *scrollytelling* narratives, freely available tools were suggested to be applied in the creation of interactive and visual content. Weekly sessions were scheduled where the students' progress was monitored, providing them with feedback from the instructors of the disciplines involved in the project (i.e., specialists in digital animation, design, and science communication). In this dynamic, students visualized their peers' work and recognized the other citizen science projects they worked on in the group. In addition, a comprehensive review of the literature on public science communication and the educational use of digital narratives was conducted by the instructors to identify effective outreach strategies that could be applied to *scrollytelling*.

S*crollytelling* effectiveness was assessed against final presentation and deliverables. Qualitative data was collected by observing the students' understanding of the socio-environmental aspects of the project created and their ability to engage and interact with a young audience, interpreted by their peers. The qualitative evaluation was carried out in a matrix in which eight proposed elements of the *scrollytelling* design were rated: 1) clear language, 2) visual communication, 3) narrative, 4) veracity, 5) scrolling functionality, 6) call to action, 7) acknowledgement, and 8) total experience. The corresponding criteria for each dimension were: 1) Uses clear, simple language and avoids complex jargon; explains technical terms when necessary; 2) Uses visuals to clearly illustrate concepts and data; keeps visuals focused, consistent, and uncluttered; 3) Structures the story with a clear start, middle, and end; 4) It shows a degree of connection with the reality of the project; 5) Up and down screen

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

dragging to show the story works properly; 6) Simplifies contacting organizers or contributing; 7) Includes expert quotes and study links; acknowledges the authors; and 8) Overall audience perception of the *scrollytelling* and citizen science story. A 1-5 Likert scale was used to measure the degree of perception of the presence of the elements in the scrollytelling, where 1 is the non-perception of the element and 5 is its maximum presence.

4. Results

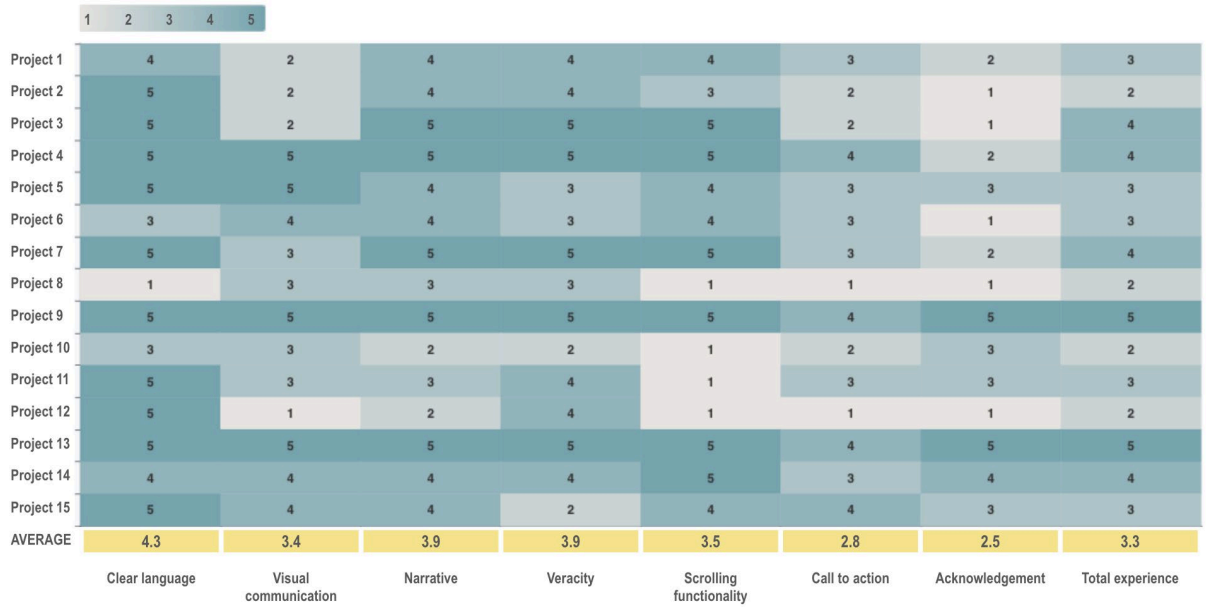
The main findings of this study reveal that *scrollytelling* as a didactic tool in the dissemination of socio-environmental citizen science projects, has proven to be highly effective in improving the understanding and engagement of higher education students. Participants were able to develop digital narratives that not only reported on citizen science projects in a detailed and accessible way, but also made them attractive to their peers, using multimedia elements that facilitated immersion and learning.

In addition, the implementation of *scrollytelling* fostered their engagement. The visual elements and narrative nature of the presentations effectively captured the attention of the audience, promoting further interaction and reflection on the projects and environmental issues discussed. Students´ positive engagement was evidenced by their feedback during the final presentations. They highlighted that the presentations in *scrollytelling* format made the socio-environmental scientific topics more accessible, awakening the desire to explore them in depth to better understand their origins. They mentioned that besides fostering a deeper topic exploration, *scrollytelling* also facilitated the collaborative construction of new insights, establishing a meaningful connection between classmates and presenters. Participants expressed significant appreciation for the opportunity to employ creative digital tools to communicate complex scientific issues, highlighting the value of *scrollytelling* as a relevant skill for their future careers and as an effective means of promoting environmental awareness. They also reflected on the potential of *scrollytelling* to transform science education, making it more accessible, interesting and relevant.

Figure 2 shows the analysis of the matrix created by the authors represented as a heatmap, where the following results were observed. In the lowest rank the element that was least perceived in the set of products was the Acknowledgement element (2.5 points), which implied including expert quotes and study links and acknowledgements to the authors. While the most perceptible element was the use of simple and clear language (4.3 points), avoiding complex jargon, as well as the explanation of technical terms when necessary. The complete matrix database including the citizen science projects´ websites can be consulted at the following link: https://doi.org/10.5281/zenodo.11069466

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 – Authors' consensus on the evaluation of *scrollytelling* projects



Source: created by author

5. Conclusions and recommendations

This study has shown the transformative potential of *scrollytelling* as a teaching tool in higher education, especially for science outreach and sustainability promotion. Through the development and implementation of interactive digital narratives that address complex socio-environmental issues, *scrollytelling* has proven to be effective in improving both the understanding and engagement of students and young people with critical issues. This digital storytelling approach, which integrates visual, textual and multimedia elements, not only effectively captures the audience's attention, but also facilitates a deeper understanding of environmental challenges, promoting meaningful and empathetic learning.

Scrollytelling can be understood as a multisensory technique offered through current technologies, which provides an immersive educational experience. However, its potential is currently limited by existing technological capabilities. With future technological advancement, an expansion in the possibilities of multisensory tools in education is anticipated (Volpe & Gori, 2019; Ferrando et al., 2022), which could be combined with *scrollytelling* by adopting the use of AI, AR and extended realities, which could transform interactive storytelling and significantly enrich students' learning and revolutionize digital pedagogies. Given these findings, it is recommended that educators and science communicators integrate *scrollytelling* into educational programmes as a key strategy to teach science and sustainability more effectively. In addition, it is suggested that training in digital tools and interdisciplinary collaboration be encouraged to enrich the creation of these narratives. For future research, it would be beneficial to explore the long-term impact of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

scrollytelling on individuals' understanding and sustainable behaviour, as well as to compare its effectiveness with other teaching methodologies. These efforts will contribute significantly to moving towards a more informed society committed to sustainability.

Acknowledgements

The authors acknowledge the financial support of Tecnologico de Monterrey through the "Challenge-Based Research Funding Program 2022". Project ID # I005 - IFE001 - C2-T3 – T. Also, academic support from Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, México.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Alexander, B. (2017). *The new digital storytelling: Creating Narratives with New Media--Revised and Updated Edition*. Praeger.

Anand, P. (2023). Spinning (Digital) stories in STEM. In Lecture Notes in Computer Science (pp. 3–11). https://doi.org/10.1007/978-3-031-35927-9_1

Bilandzić, H., Kinnebrock, S., & Klingler, M. (2020). The Emotional Effects of Science Narratives: A Theoretical framework. *Media and Communication*, 8(1), 151–163. https://doi.org/10.17645/mac.v8i1.2602

Burns, T., O'Connor, D. J., & Stöcklmayer, S. (2003). Science Communication: a Contemporary Definition. *Public Understanding of Science*, 12(2), 183–202. https://doi.org/10.1177/09636625030122004

Dahlstrom, M. F. (2014). Using narratives and storytelling to communicate science with nonexpert audiences. *Proceedings of the National Academy of Sciences of the United States of America*, 111(supplement_4), 13614–13620. https://doi.org/10.1073/pnas.1320645111

Dancsa, D., Štempelová, I., Takác, O., & Annus, N. (2023). Digital tools in education. *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(4), 289–294. https://doi.org/10.59287/ijanser.717

Ferrando, S., Volta, E., & Volpe, G. (2022). Multisensory Technologies to Support Teaching: an Ongoing Project. *Interaction Design and Children*. https://doi.org/10.1145/3501712.3535284

Gain, A. K., Giupponi, C., Renaud, F. G., & Vafeidis, A. T. (2020). Sustainability of complex social-ecological systems: methods, tools, and approaches. *Regional Environmental Change*, 20(3). https://doi.org/10.1007/s10113-020-01692-9

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Kelly, G. J. (2014). Discourse Practices in Science Learning and Teaching. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of Research on Science Education: Vol. II* (First, pp. 321–336). Routledge.

Khatibi, F. S., Dedekorkut-Howes, A., Howes, M., & Torabi, E. (2021). Can public awareness, knowledge and engagement improve climate change adaptation policies? *Discover Sustainability*, 2(1). https://doi.org/10.1007/s43621-021-00024-z

Krauss, J. E., Mani, S., Cromwell, J., Pineda, I. S. R., & Cleaver, F. (2022). Bringing research alive through stories: reflecting on research storytelling as a public engagement method. *Research for All*, 6(1). https://doi.org/10.14324/rfa.06.1.20

Kumpu, V. (2022). What is Public Engagement and How Does it Help to Address Climate Change? A Review of Climate Communication Research. *Environmental Communication*, 16(3), 304–316. https://doi.org/10.1080/17524032.2022.2055601

Moser, S. C. (2014). Communicating adaptation to climate change: the art and science of public engagement when climate change comes home. *WIREs Climate Change*, 5(3), 337–358. https://doi.org/10.1002/wcc.276

Nisbet, M. C. (2009). Communicating climate change: Why frames matter for public engagement. Environment: Science and Policy for Sustainable Development, 51(2), 12–23. https://doi.org/10.3200/envt.51.2.12-23

Nisbet, M. C., & Scheufele, D. A. (2009). What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10), 1767–1778. https://doi.org/10.3732/ajb.0900041

Parola, A., Di Fuccio, R., Somma, F., & Miglino, O. (2022). Educational Digital Storytelling: empowering students to shape their future. In *Communications in computer and information science* (pp. 119–129). https://doi.org/10.1007/978-3-031-15845-2_8

Robin, B. (2016). The power of digital storytelling to support teaching and learning. *Digital Education Review*, 30, 17–29. https://doi.org/10.1344/der.2016.30.17-29

Stevenson, R. B. (2022). Approaches to Education for Sustainability. *Oxford Research Encyclopedia of Education*. https://doi.org/10.1093/acrefore/9780190264093.013.93

Volpe, G., & Gori, M. (2019). Multisensory Interactive Technologies for Primary Education: From Science to Technology. *Frontiers in Psychology*, 10. https://doi.org/10.3389/fpsyg.2019.01076

Wals, A., & Jickling, B. (2002). "Sustainability" in higher education: from doublethink and newspeak to critical thinking and meaningful learning. *Higher Education Policy*, 15(2), 121–131. https://doi.org/10.1016/s0952-8733(02)00003-x

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: a reference framework for academic program development. *Sustainability Science*, 6(2), 203–218. https://doi.org/10.1007/s11625-011-0132-6

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Watershed and Place-Based Environmental Pedagogies

Judith Madera[a], David Phillips[b]

[a] Wake Forest University, Department of English, African American Studies, USA
[b] Wake Forest University, Program in Interdisciplinary Humanities, USA

Abstract

This paper discusses an integrative course pilot for university students in environmental humanities with a specific focus on the relationship between wetland conservancy and human environmental systems. It describes ways to facilitate qualitative, experiential research into community wetlands. Wetland habitat loss necessitates a more enhanced understanding—not just of water hydraulics and management—but of water's human significance and perceptual public value. Since ecologies are constituted by the ways they are used and the ways they are shared, we argue that it is important for environmental educators to approach concerns about freshwater security and longevity through the lens of place- based pedagogies. A number of related questions are targets of application: How can we better come to terms with our localized dependencies on wetlands? What can a place-based approach teach us about the need for symbiotic strategies for living with water rather than defensive ones? How do we make our understandings of diverse water sources and their biomes a critical and contemporary learning competency? What are some deliberate modes of thinking (historical, representational, design-focused) that will better orient us for future challenges? Approaches to these questions are cued in the discussion as well as insights into bioregional awareness and place-based environmental praxis.

Keywords: place-based pedagogy; wetlands; watershed; critical cartography; environmental praxis.

How to cite: Madera, J. and Phillips, D. (2024) Watershed and Place-based Environmental Pedagogies. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 759-767.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Fresh water scarcity is predicted to be one of the most defining problems of the 21st century. Throughout much of the world, demand for fresh water outstrips availability. Concerns are projected to intensify by the middle of this century, and longstanding management practices have only aggravated the problem. In the United States, geologists estimate that since the beginning of the nineteenth century, over half of the country's wetlands have been drained or flooded for agriculture, real estate, and canals. Yet, despite our widely accepted understandings of the essential life-supporting functions of wetlands, their ongoing devastation (and attendant pollution and diminution) demands new approaches and resources.

Wetland habitat loss necessitates a more enhanced understanding—not just of wetland hydraulics and management—but of water's human significance and perceptual public value. Since ecologies are constituted by the ways they are used and the ways they are shared, we argue that it is important for environmental educators to approach the nexus of water and community through the lens of placemaking and place-based experience. Core questions posed in this paper include the following: How can we better come to terms with our dependencies on wetlands? How do we make our understandings of diverse water sources a critical and contemporary learning competency? What are some deliberate modes of thinking (historical, representational, design-focused) that will better orient us for future challenges? We will cue a number of approaches to these questions by discussing an integrative course pilot for university students in environmental humanities that focuses on the relation between wetlands and human environs.

At the outset, it is useful to specify a practical observation that informs both the problematic and demographic we are identifying: For many students entering into the university, a significant portion of their academic learning (particularly in terms of content and approaches to analysis) has not been grounded in an awareness of local ecosystems. Oftentimes, lessons are not "sourced locally." (Hagood, 2016) Home ecologies are material negotiations that inform epistemes and interactions with the world. But in terms of establishing a framework for environmental praxis, many U.S. college (post-secondary) students demonstrate a better understanding of political and economic boundaries than they do of ecological ones. They cannot describe local watersheds; they do not know where their household drinking water comes from or where it goes once it reaches the drain. They do not know the basic geologies of their home-places. Climate change, superstorm events, and flood risk are certainly chipping away at notions of an invulnerable habitat. But when it comes to the kinds of wetland, coastline and ecotonal systems that contour various community experiences, students often lack a target of application for their environmental knowledge. This

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

disconnect is double-edged. It is a disconnect between individuals and the wider ecosystems their lives depend on—and there is a gap in what constitutes educational competency and watershed awareness.

We raise these points in the first part of this discussion because a major pedagogical objective underpinning this project is praxis-based. It is about fostering place-based pedagogies—approaches to learning that facilitate student explorations of local environments. Put simply, different locales can support different kinds of learning. (Abram, 2011) Too often, scholarly analysis does not account for specificities beyond the merely generalizable or the extractable. But in this gap, ecotonal histories and life-sustaining water cycles can be lost. Places can be expropriated, rezoned, or radically altered. So we need better ways to establish understandings between communities and their waterways.

In terms of scale, what is considered local does not need to be constrained to a particular municipality or political boundary. Rather, we purpose the term to indicate a commitment to approaching place as something constructed through encounters, something exercisable and experiential. Capital-intensive engineering projects or imposed technological fixes designed to control water are simply no substitute for user-based place awareness. Local place knowledge, however, is a foundational component for addressing second-order challenges like water conservancy and reclamation.

2. Methodology and Locale

Place-based pedagogy takes a variety of forms. For environmental educators, a place-based study of human culture and wetlands would extend beyond the classroom. It would get students into the field to better understand the river tributaries and life biomes they utilize in their daily lives. Place-based education is a mode of applied learning. It requires real-world interaction and opportunities for reflection. Such approaches can help students define their positions as stakeholders in the environments they inhabit.

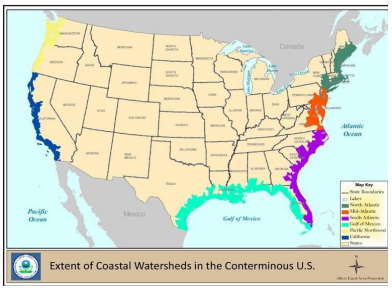
We began from the starting point that water determined the quality of life for all life. A National Endowment for the Humanities (NEH) grant in Engaged Humanities (2018/2019) provided us the opportunity to co-design and co-pilot an applied humanities course about wetlands and floodplains at Wake Forest University in Winston-Salem, North Carolina: "Liquid Landscapes: Designs Networks and Stories." Winston-Salem lies in the Piedmont region of the state, bordered by the Appalachian Mountains and the Atlantic Ocean. About 80% of its drinking water comes from the Yadkin-Pee Dee River Basin. As we pointed out, the water in students' drinking bottles originated in the mountains of Blowing Rock, N.C. and extended some 18, 648 sq. kilometers to the Atlantic coast in the low country bay of Winyah, South Carolina. The water is threatened by industrial contaminants, farm runoff, and poor

BY-NC-SA 2024, Editorial Universitat Politècnica de València

management. (Ringwold, 2016) With this as our shared ecosystem, the course was an effort to bring broader attentiveness to wetland attrition and to encourage site-specific sustainability strategies.

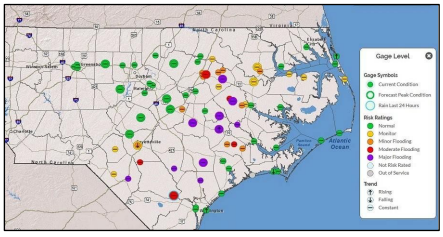
In our pilot seminar, our focus was primarily on waterways in North Carolina and along the Atlantic seaboard from New York to the Antilles in the Caribbean, where wetland attrition currently outpaces much of the western hemisphere.† Through sequentially-planned learning units, community partnerships, integrative digital work, and collaborative research opportunities, students were invited to explore water as a resource that prompts significant questions about human and ecological relationships. Our overall aim was to facilitate humanities-driven research into wetlands, and to provide students with a framework for understanding the ways water shapes community experiences.

Fig. 1 – "Extent of coastal watersheds in the coterminous U.S."



Source: U.S. Environmental Protection Agency. December, 2016 .
https://www.epa.gov/wetlands/coastal-wetlands

Fig. 2 – Hurricane Matthew Aftermath



Source: NC Flood Inundation Mapping and Alert Network (NC FIMAN)
https://www.rt.com/usa/362709-nc-hurricane-matthew-flooding-rivers/

3. Environmental Pedagogical Frameworks

3.1 Bioregionalism and Experiential Learning

Too often the notion of a bioregion is taken to be something atomistic—a scission space or a discrete ecological entity. But our approach was grounded in both local and liminal understandings of marine systems. To be sure, local environmental decisions, whether they

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

be regarding runoff or wetland preservation, rarely fall into a singular set of pre-zoned boundaries. Instead, they prompt questions of freshwater connection and causation. As Neubauten et. al. (2024) point out, sustainable management is rarely the purview of transnational organizations, but nature's contributions to people "(such as water quality regulation, flood mitigation, and carbon storage) cross national borders, as do many species (migratory birds, wide-ranging mammals)." (Neugarten et al., 2024) Groundwater in reservoirs, lakes and rivers also needs to be understood as a system of channels and flows. So it was critical to relate it to wider ecological circuitry. From a place- based perspective, it was helpful to discuss ocean estuaries and mountain headlands alike as different points of entry into an interconnected system. For this reason, our course opened with a discussion of the powerful Atlantic Hurricane Matthew (2016) and its broader impact on the Caribbean (Haiti, the Dominican Republic, St. Vincent and the Grenadines) as well as the Southern United States and its coastal estuaries. After situating the U.S. South in a regional frame shared with the Caribbean archipelago, we discussed the impact of hurricane-related flooding in North Carolina.

Using humanistic, qualitative methods from literary study (interpretive description, close reading, collecting subject testimony, identifying stance, understanding arguments through evidenced forms) we asked students to apply their understandings of bioregions to the sorts of massive humanitarian crises prompted by climate change and extreme weather events. What kinds of place-based vulnerabilities do we share? What new modes of adaptation must be considered, and how do we think about our values in relation to the infrastructures of water? A key goal of this unit was to elicit our students' experiential understandings of community needs and geo-relationality. To this end, we introduced the class to media archives that collected, preserved, and shared regional stories of hurricane displacements and rising seas. Human testimonies of displacement were powerful tools for gaining an appreciation of risk and vulnerability. Students began to think about the ways our stories could both preserve the past and help us find new approaches to rebuilding.

3.2 Modes of mapping: exploration, critique, and meta-cartography

Throughout different course units, students gained basic practice in incorporating geographical data and inventory into arguments. They developed ways to both narrativize and visualize geography through basic GIS literacy (Geographical Information Systems) and interactive map use. Mapping something as fluvial and shifting as wetlands, however, presented a number of challenges. GIS is an adaptable tool to aid in classroom explorations and curations of discoverable sites. But in terms of geo-historicizing local (Winston-Salem) urban development in conjunction with natural networks created by its waterways, students discovered that the relationship between wetlands and urban memory could be fraught.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Utility often informs public memory. Part of our local outreach involved hosting a local environmental planner and a local community historian from a neighboring college to meet with our students. Their approaches to community waterways preservation were quite different. A practical finding from this experience was that aims for restoration and renewal (including new developments) do not always move in tandem. But community advocacy was important for achieving both enhanced awareness and greater protection.

A less-anticipated—albeit fruitful—outcome of our mapping exercises was the way it provided an inroad into meta-cartographic observations. In our case, we considered the more tangential and speculative features of mapmaking, including attributions of scale and value. Where might city planners have intervened to protect the health of a waterway? How did something as seemingly neutral and representative as a map reflect socio-economic choices or zoning for private interests? As critical cartographer Denis Wood has argued, "as long as we conceive of maps as representations, our imagination will be fettered by the received picture of the world." (Wood, et al., 2010) Maps can simultaneously be reflections of physical facts and reflections of anthropocentric value. So a scholarly takeaway from this project was developing a changed sense of analytic through pedagogy: approaching representational models—not as facts on file—but as lenses and optics. Maps tell stories, and stories can change.

3.3 Place-making as intervention

Facilitating a forum for an open discussion about possibilities and options for the Piedmont region's waterways set the stage for students' creative insertions into waterway projects as "interventions" that enabled placemaking. Working in teams, students proposed an environmental intervention that would add a layer of meaning to their chosen waterway.

They alternately recorded videos or wrote multimedia presentations with a one-page tear-out sheet describing their project as if it were a placemaking proposal being presented to the city or municipality most appropriate for their recommendation.

The course culminated in a place-based term project in public humanities. The project was staged developmentally so that it allowed students to gain practice in placemaking and in working collaboratively with a team to produce a tributary history of Winston-Salem. In Stage 1, students were asked to document the location of the waterway/waterway network and related archival materials that would enrich the class's understanding of its cultural history (including photographs and texts). While archival traces were not always abundant (and in some instances, apparently nonexistent) a core methodology from the speculative mapping approach became a way to think forward new stories. As Sandra Postel reminds us: "We can choose to write a new water story. Depletion and dead zones are not inevitable." (Postel,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2017) Students could opt instead to provide a speculative narrative (a projected story based on archival information) of the ways in which a person, family, or neighborhood group meaningfully interacted with the waterway. Stage 2 flowed from the first stage; members of each team were then responsible for leading a Q&A (question and answer short session) following their watershed presentations. Though we provided different suggestions about local waterways and site markers, students in our pilot seminar largely elected to choose their own sites and compose their own media-rich narratives of place. We felt encouraged by student-driven initiatives and their diverse site selection strategies. It fulfilled a course objective: to reimagine wetland dependencies and develop a first-person appreciation for our shared freshwater systems.

4. Chronology and Outcomes

The place-based exercises that students engaged in enabled them to achieve three important outcomes: first, they applied humanities methodologies to experiential modes of investigation, developing a deeper understanding of the role of place in explicating the relationship of people to the environment; second, they problematized the hierarchies of environmental control and resource extraction that have traditional placed societies in a position of dominance over the environment; third, they engaged in place-making strategies to transform communities' relationships to water-based environments.

Students developed the critical skills to explore what it means to "know" a place, first exploring the narratives of populations impacted by natural and man-made disasters. Their interpretive tasks included applying place-based methodologies to analyze stories of climate refugees and victims of environmental injustice. Next, they devised place-making strategies in a series of experimental design intervention proposals for local waterways and water biomes. These interventions included historical and geographical/topographical research projects to reconnect people to place as they devised strategies for the reinvestment of the public in these places. These interventions were devised to engage local community members in an examination of the role that waterways can play in strengthening a community's sense of place identity.

Class members next initiated a discovery process where they drafted autobiographical narratives of their relationship to the natural world, reflecting on what their reflections on these personal encounters have taught them. Their investigative process continued with "restructuring viewpoints," a set of exercises focused on examining place-based personal narratives that reveal people's relationship to water, and documenting these first-person narratives of belonging and the perspectives that informed these relationships. Many of the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

stories focused on instances of environmental loss. Loss catalyzed the stakes of belonging, and a growing student interest in protecting vulnerable places that mattered to them.

The class continued their application of place-based methodologies by exploring local environmental contexts, approaching place as something constructed through encounters. By extending the classroom into the community, students were encouraged to reflect on our shared position as stakeholders in the environments we co-inhabit. A visioning workshop provided a bridge to constructing a future where student groups could posit how forward-thinking environmental policy could positively impact quality of life. They completed the course with proposals for design interventions. These involved transforming narratives of environmental loss into ones of reaffirmation, including a team's presentation on resiliency strategies that emerged as communities attempted to integrate their neighborhoods in fragile barrier island communities with the surrounding aquatic environments; another team explored the transformative role that daylighting buried waterways can play in creating new place memories and reintegrating communities with "lost" histories of place through rediscovered waterways.

5. Conclusion

The fields of spatial and environmental humanities are disciplinary realms that examine how constructed values dictate human conceptualization and use of space, including both natural place-based features (our environmental context) and human-made features that constitute our built spaces. One of the goals of such disciplinary knowledge is to better understand human relationships to place, waterways, and environment. By mapping, visualizing, and narrativizing places, the relationship between a community and its waterways becomes more concrete. "Liquid Landscapes" was designed to model some of the challenges that human intervention in the environment enables in altering our physical world. It also aimed to present pedagogical opportunities for collaborating with other educational institutions, public sector specialists, and entities in a set of engaged humanities exercises and structured learning contexts. There are many benefits to place-specific, engaged learning, particularly because this approach helps students define their positions as stakeholders in the environments they use and plan to inhabit. In an epoch of acute environmental crisis, environmental educators are doing the practical work of educating future policy makers, practitioners and changemakers.

As educators, we came away from the course with a greater appreciation of the relationship between humanities praxis and watershed preservation. The humanities invite us to excavate who we are in time and place, and project new understandings for collective futures. We also gained a more acute and practical appreciation for what environmental literacies entailed.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Environmental literacy ultimately means making biotic communities legible in a variety of ways. It is a praxis that can strengthen strategies for reading and comprehending our multifaceted relationship to the natural world.

Acknowledgements

This project was supported by the National Endowment for Humanities (NEH) Engaged Humanities Grant and Wake Forest University Humanities Institute.

Conflicts of interest

The authors declare no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Hagood, A. & Price, C. (2016). "Classroom ecotones: Connecting place-based pedagogy and blended learning" *ISLE*, 23(3), 603-625. https://doi.org/10.1093/isle/isw043.

Abram, D. (2011). *Becoming animal: an earthly cosmology.* Vintage Books. Ringwold, A. (2016). "Watershed protection for the Yadkin"

https://www.yadkinriverkeeper.org/news/2019/1/30/watershed-protection-for-the-yadkin

Neugarten, R.A., Chaplin-Kramer, R., Sharp, R.P. et al. (2024). "Mapping the planet's critical areas for biodiversity and nature's contributions to people." Nature Communications, 15, 261. https://doi.org/10.1038/s41467-023-43832-9

Wood, Denis with Fels, J. and Krygier, J. (2010). *Rethinking the Power of Maps.* The Guilford Press, 39.

Postel, S. (2017). *Replenish: The Virtuous Cycle of Water and Prosperity*. Island Press, 245.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Reflecting on Addressing Academic Integrity through Authentic Assessment

Sharon Lehane[a], Angela Wright[b]

[a]Department of Management and Enterprise, Munster Technological University, Ireland
[a]Office of VP Academic Affairs, Munster Technological University, Ireland

Abstract

With the advancement of Artificial Intelligence and chatbot technologies such as ChatGPT, little else is discussed currently by colleagues in Higher Education. Why? – because their potential disruption for assessment practices in higher education are so uncertain. Advances in these artificial intelligence technologies threaten the legitimacy of assessment and academic integrity, calling conventional assessment methods into question. The widespread utilisation of ChatGPT emphasizes the need for sustainable educational practices such as authentic assessments that focus on higher-order critical thinking and problem-solving skills. In terms of the methodology for this study, a critical examination of the association between authentic assessment design and academic integrity was initially conducted, as part of a systematic literature review, analysing 32 focused publications from 2019 to 2023. Key theoretical perspectives on improving academic integrity through authentic assessment design were identified and critiqued, which led to the development of a robust 'Model for Practice' along with a weekly implementation plan. This model was used to structure the teaching and assessment schedule for two final year student groups (129 students). Using Gibb's Reflective Cycle (1998), the lecturer has engaged in a self-evaluation and reflected on the process of implementing the model to identify key areas for improvement. Suggested improvements to the weekly implementation plan are presented in this study to refine practice and ensure that the authentic assessment design aligns with current pedagogical needs, while being resistant to academic misconduct.

Keywords: Academic Integrity; Artificial Intelligence; ChatGPT; Authentic Assessment and Design; Contract Cheating; Reflection

How to cite: Lehane, S. and Wright, A. (2024) Reflecting on Addressing Academic Integrity through Authentic Assessment. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 768-776. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The sudden arrival and mainstream usage of artificial Intelligence bots such as ChatGPT has resulted in a dearth of research into the relationship between assessment design and the impact of artificial intelligence chatbots on academic integrity for higher education providers. These chatbots are permeating the higher education landscape with widespread uncertainty on the possible implications for higher education, with some studies warning of a potentially catastrophic impact on assessment, and others stating that ChatGPT may bring opportunities in terms personalised learning, immediate feedback and assisting educators. Higher education institutions are increasingly expected to produce 'employment ready' graduates, which positions authentic assessment as a primary tool for developing students' professional skills. The acquisition of these employability skills; however, is reliant on assessment practices that hold students to the highest academic standards. The legitimacy of a higher education institution will be undermined if the institution cannot guarantee that an assessment accurately measures student learning. Empirical evidence is urgently required to determine the optimal authentic assessment strategy for deterring academic misconduct, as there is a lack of findings which specifically explore the association, and this paper aims to address that gap.

2. Research Context: Authentic Assessment and Academic Integrity

Over the past three decades, higher education scholars have continuously advocated for the increased implementation of authentic assessment (Ajjawi *et al.*, 2023). Authentic assessment is defined as 'assessment which aims to engage students in real-world scenarios that are complex, ambiguous, and unpredictable, to simulate the real-life situations and problems that students will face in their careers (Bretag *et al.*, 2019). Authentic assessment has emerged as an alternative to standard exams, and aims to assist students in contextualising their learning, encourage internal motivation, promote inclusion, and improve higher-order critical thinking and problem-solving skills (Sotiriadou *et al.*, 2020). Bretag *et al.*, (2019) define academic integrity as compliance with ethical, moral, and professional principles, values and standards that serve as guidance for making decisions and taking action in education, research, and scholarship institutions. There is growing awareness among educators of new academic misconduct practices, such as contract cheating involving a third-party completing work for the student; however, there are no definitive answers on how to reduce, manage and penalise academic misconduct and it is not clear how many assignments are procured through a third-party. The credibility of academic standards in higher education is threatened by academic misconduct, leading regulators globally to urgently explore potential solutions. Maintaining the trust placed in assessment and its ability to ensure that students have demonstrated learning to a level that is worthy of a qualification is critical, and it is proposed that authentic assessment should be at the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

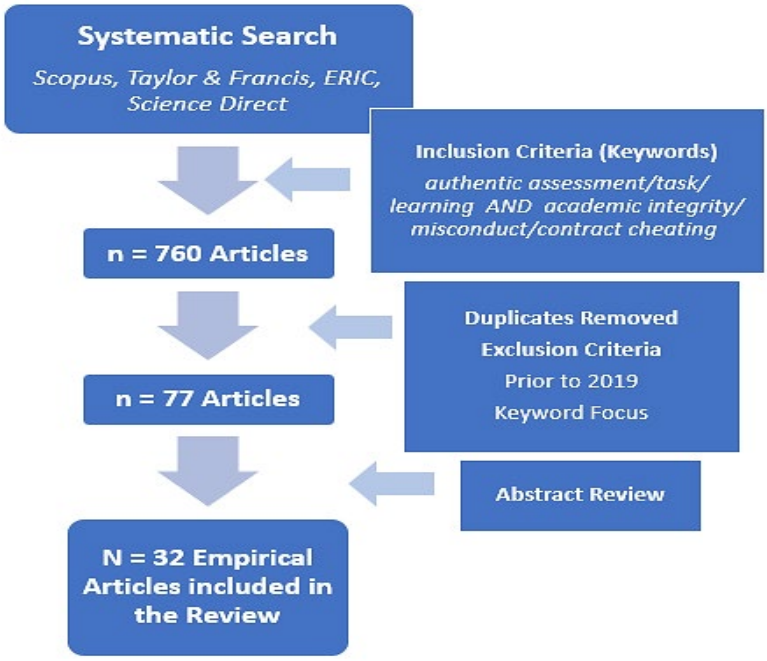
forefront of an assessment movement that addresses student equity, artificial intelligence, and academic misconduct (Ajjawi *et al.*, 2023). Studies have challenged the view of authentic assessment as an academic integrity panacea; authentic assessment may reduce academic integrity breaches, but there is no one assessment that can prevent it and the assessment type itself is not enough to address academic misconduct (Bretag *et al.*, 2019). Moreover, the real-world, career-focused, complex problem-solving task aspects of authentic assessment may be overly complicated for academically and lingually diverse students and lecturers may not have resources to provide scaffolded support to students (Ellis *et al.*, 2020). Nevertheless, there is sustained interest in authentic assessment, and its place in the pedagogical environment cannot be disputed. This paper aims to address the question of authentic assessment's value as a potential solution for academic misconduct in higher education.

3. Methodology

3.1 Systematic Literature Review

To gain an understanding of the concepts at play in this field a systematic literature review was employed initially, using key searches, rigorous inclusion criteria, and comprehension evaluations (Figure 1). Journals after 2019 were utilised, due to the plagiarism focus prior to this, and to understand new cheating practices. Keywords were selected to ensure that all relevant papers would be returned while accounting for differing terminology globally and across disciplines. 760 initial results were limited to 32 articles, which were analysed in detail.

Fig. 1 – Systematic Literature Review



Source: Own elaboration

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

This systematic and critical literature review identified a dearth of authentic assessment designs that grapple with the complexities of the new academic integrity landscape. A thematic analysis was conducted to identify key theoretical perspectives on improving academic integrity through authentic assessment design; summarised in Table 1.

Table 1 – Systematic Literature Review: Authentic Assessment: Improve Academic Integrity

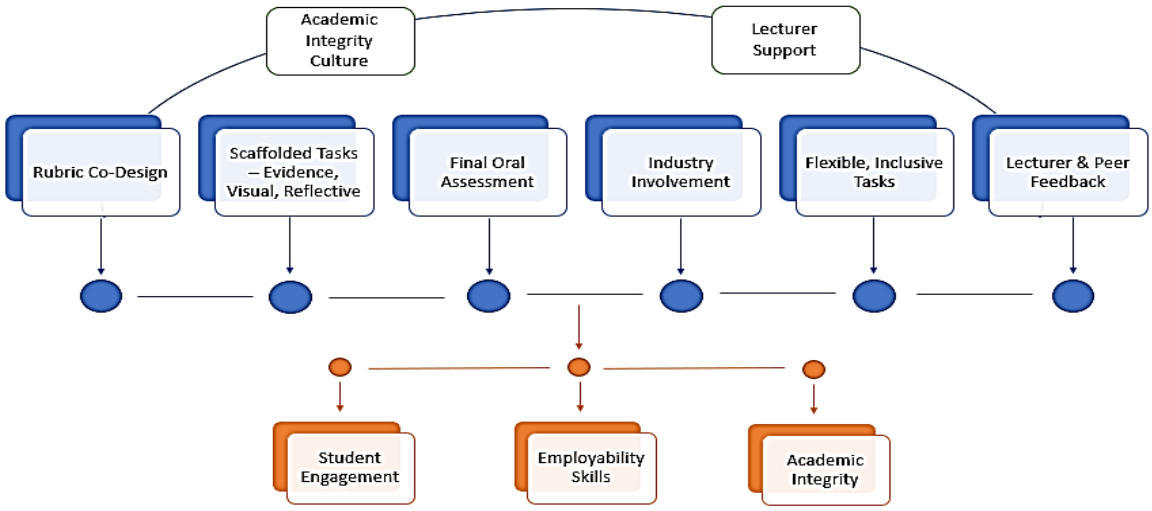
Theoretical Perspective	*Authentic Assessment*	*Academic Integrity*	*Main Authors*
Well-Timed, Personal, Unique Tasks	Adequate time, Personalised; Evidence gathering	Meaningful; Verifies participation; Peer pressure	Sotiriadou *et al.,* 2020
Engagement	Active contribution; Students as partners	Motivation; Partnership gives students support	Bretag *et al*., 2019; *Ellis et al.,* 2020
Complexity	Scaffolded complex tasks; Group work; External engagement	Difficult to outsource complex tasks; External scrutiny	Bretag *et al.,* 2019; Ellis *et al.*, 2020
Teaching & Learning Environment	Personalised teaching, feedback; Student-lecturer relationship; Clear assessment requirements	Lecturer detection due to student ability awareness; Early identification of struggling students	Harper, Bretag and Rundle, 2021
Scaffolding	Distinct, interconnected, progressive, reflective assessment components	Subsequent progressive tasks; Reflecting on class and group sessions; Feedback on each task	Bretag *et al.,* 2019; Ellis *et al.*, 2020; Sotiriadou *et al.,* 2020
Support/ Instructional Material	Assessment support; Clear instructions; Lecturer recordings; Exemplars; Rubrics; Training	Expectations clarified; Student understanding of assessment requirements and marking criteria	Sotiriadou *et al.,* 2020
Inclusion	Assessment and Rubric Co-Design	Refine assessment design; Adapt to learning styles	Sotiriadou *et al.,* 2020
Feedback	Peer feedback; Feed-forward	Familiarity with work; Learning Ownership; Student-lecturer dialogue	Bretag *et al.,* 2019
Industry Partners	Partner with a company; Real-world setting	Presenting externally; Employment opportunities	Ellis *et al.,* 2020
Culture	Assessment Design to minimise cheating; Supportive environment	Promote academic integrity culture and visuals; Dedicated staff	Ellis *et al.,* 2020
Assessment Type	In-Class Tasks; Personalised work; Orals/Vivas; Reflections	Random nature of lecturer questions; Defending personal work	Harper, Bretag and Rundle, 2021

Source: Own elaboration

Six characteristics are recommended as essential authentic assessment design features, and these emerge specifically from the in-depth literature explored. The framework (Figure 2), developed from this work, displays these characteristics. The authors believe that this new design framework will minimise academic misconduct and improve student engagement and future employability skills. For the ultimate success of the framework, its implementation must be supported by a holistic academic integrity culture and lecturer assistance.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 2 –Design Framework: Authentic Assessment



Source: Own elaboration

3.2 Implementation [Reflective Stage – Description (Gibbs, 1988)]

The authentic assessment characteristics and theoretical perspectives were broken down into a weekly implementation plan for a 13-week semester (Figure 3) and executed with final year student cohorts consisting of two groups; Marketing (97 students); Home Economics and Business (32 students); with both cohorts undertaking a mandatory Strategy Module.

Fig. 3 – Authentic Assessment Weekly Implementation Plan

Week 1	• Introduction to Industry Partners and Real-World Issue • Students form Groups	Week 7	• Students Submit Draft Assignments
Week 2	• Online Discussion Forum for Rubric Co-Design • Workshop for Rubric Co-Creation	Week 8	• Students Provide and Receive Feedback on Drafts
Week 3	• Rubric Finalised • Lecturer Recording Explaining Assessment Criteria	Week 9	• Lecturer/Student Meetings to Provide Feed-Forward
Week 4	• Student Reflection on Rubric Co-Design Process	Week 10	• Students Finalise Assignments
Week 5	• Students Gather Evidence, Create Mindmaps/Storyboards	Week 11	• Student Presentations
Week 6	• Workshop - Students Critique Past Exemplars	Week 12	• Student Reflection on Authentic Assessment Experience

Source: Own elaboration

A relatively new local enterprise space was the chosen industry partner, called the Marina Market, a local market near to the University. This unique space is an old warehouse in the city docklands area and has an indoor food hall with forty permanent vendors. The lecturer checked with the students that they had all visited the Marina Market before deciding on this partner. Then, representatives from the Market presented to students and sought unique event ideas for their venue. Students formed groups and participated in a rubric co-design

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

workshop where they were provided with a past assignment rubric and asked to suggest changes individually using an online discussion forum on the learning management system, Canvas. Students could not view suggestions from their peers until they commented. Marks for this element (5% of the module) depended on the critical thought process leading to the suggestions. The lecturer analysed all comments, altered the rubric, and recorded a tutorial on Canvas explaining the rubric, marking criteria and all assignment requirements. The main task (32%) was to carry out a strategic analysis of the Marina Market and students proposed that this be presented in a 'scrapbook' document, consisting of a mix of visuals to evidence their learning and analysis in text format. The lecturer facilitated an exemplar workshop, where students reviewed past assignment examples, ranked them, and provided critical feedback. The presentation (30%) focused on the students' event idea for the Marina Market, aligning with industry partner requirements. Students submitted drafts of their event ideas anonymously to Canvas, each idea was reviewed by two peer groups, and feedback returned anonymously. Marks for the peer feedback process (8%) depended on the quality of the feedback provided. Lecturer-student feed-forward sessions took place before completion of the scrapbooks and presentations. Finally, students reflected on the experience (25%) and expressed their thoughts on how the authentic assessment design could be improved. Student reflections are currently being analysed in depth; however, the initial findings from these reflections, along with the lecturer's reflection for practice, are presented in this paper.

4. Initial Findings [Reflective Stages – Feelings and Evaluation (Gibbs, 1988)]

Feelings - Students indicated that the overall process reduced their motivations to cheat as they felt more engaged, motivated, and enthusiastic. There was strong attendance at the rubric co-design workshop, and students felt that involving them allowed their voice to heard and showed that their opinion was valued. The industry partner's event idea allowed students to develop events targeting their demographic, which students thought was inclusive and meaningful. The top event ideas were chosen by the Marina Market and the potential opportunity to be chosen as a finalist served as a further motivator for students. Students felt the progressive, scaffolded nature of the tasks reduced opportunities to cheat as they had to understand the previous task to move forward. Students enjoyed the immersive nature of the assessment which involved visiting the Marina Market and gathering visuals to evidence learning. Students were extremely encouraged by the lecturer-student feed-forward sessions and felt that these were invaluable to their learning.

Evaluation - The students would have liked more time with the lecturer at feed-forward sessions to ensure that their work could be analysed in more detail. Similarly, the lecturer believed these sessions were rushed given the large student numbers. Several students expressed regret at their lack of participation in workshops and feed-forward sessions, as they realise that these integral learning opportunities were missed. Both students and the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

lecturer were disappointed with the exemplar workshops, as the exemplar assignments were 'report' format rather than 'scrapbook' style. Students were confused about what was expected of them in relation to the scrapbook as they had never completed one before, and the lecturer could not provide an exemplar in this format, as it was the first time this assessment type was used. The lecturer also felt it was difficult to meaningfully engage with each student group during both the rubric and exemplar workshops, given the large number of students attending. A number of students were dissatisfied with their presentation skills, although the lecturer did not agree in some instances. Students suggested that positive comments should be included in the peer feedback process as they thought their peers were overly focused on the negative aspects of their event ideas. The lecturer believed that students' final reflections could have been deeper and more critical of their own actions.

5. Discussion [Reflective Stages – Analysis, Action Plan & Conclusion (Gibbs)]

Analysis and Action Plan – Encouraging all students to meaningfully participate in the authentic assessment process will ensure that their learning and skill development benefits and their temptation to engage in academic misconduct reduces. The lecturer could provide a clearer outline of the authentic assessment process at the start of the semester to engage as many students as possible from the outset, reminding them that they will need to deeply reflect on the process at semester end and informing them of past students' regrets at their lack of participation. Although students were not dissatisfied with the industry partner, the lecturer has decided to allow the students to choose the industry partner in future iterations. Students will suggest companies to work with and vote on one to ensure the process is more flexible and inclusive. Student comments could be sought on the lecturer's tutorial recording to ensure that all students clearly understand the assignment requirements. The lecturer will split the student groups for future workshops to ensure that all students are learning from the process, and to allow for verification of participation. Scrapbook exemplars will be available for future exemplar workshops and permission will be sought from the students responsible for the work. The peer feedback template will be adjusted where students will be asked to firstly comment on the positives of their peers' work. Lecturer-student feed-forward sessions will be run over two weeks to ensure that the lecturer can meet each student group twice - the first meeting will concentrate on proposed changes and the second meeting will allow for a more detailed analysis of students' work. The lecturer will inform students that they will only be asked questions on the element of the presentation that they delivered, in order to put students more at ease. Additional time will be given to training on reflection to ensure that students are equipped with the necessary skills to provide a critical reflection.

Conclusion – The lecturer believed that the proposed framework and implementation plan allowed her to become very familiar with students' work through verifying rubric suggestions, discussions at workshops and feed-forward sessions, and questioning students at

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

presentations, all of which made it difficult for students to cheat. The overwhelming majority of students believed that the Marina Market 'live case' improved their engagement with the module, enhanced their employability skills, and helped with academic integrity guidelines. Students believed they could approach the lecturer for support, they felt they received sufficient feedback, and they clearly understood the assessment requirements, despite initial confusion with exemplars. The authentic assessment framework helped to create a supportive and collaborative learning environment which led to the anticipated framework outcomes being met – improving engagement, employability skills and academic integrity.

6. Limitations and Conclusion

Student reflections continue to be analysed to further probe student views on the experience and improve practice. The framework developed in this study lays the foundations for the emergence of evidence-based approaches to authentic assessment design that foster academic integrity across multiple disciplines and will be a useful tool to offset assessment disruption. Reflecting on the optimal authentic assessment design has led to the proposal of changes that will ensure the framework and implementation plan are considered as potential solutions to the issue of meaningfully assessing students in a new ChatGPT landscape.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Ajjawi, R., Tai, J., Dollinger, M., Dawson, P., Boud, D., & Bearman, M. (2023). From authentic assessment to authenticity in assessment: broadening perspectives. *Assessment & Evaluation in Higher Education*, 1–12. https://doi.org/10.1080/02602938.2023.2271193.

Bretag, T., Harper, R., Burton, M., Ellis, C., Newton, P., van Haeringen, K. & Rozenberg, P. (2019). Contract cheating and assessment design: Exploring the relationship. *Assessment and Evaluation in Higher Education*, 44(5), 676–691. https://doi.org/10.1080/02602938.2018.1527892.

Ellis, C., van Haeringen, K., Harper, R., Bretag, T., Zucker, I., McBride, S., Rozenberg, P., Newton, P., & Saddiqui, S. (2020). Does authentic assessment assure academic integrity? Evidence from contract cheating data. *Higher Education Research and Development*. https://doi.org/10.1080/07294360.2019.1680956.

Gibbs, G. (1988) *Learning by Doing: A Guide to Teaching and Learning Methods* Further Education Unit, Oxford: Oxford Polytechnic.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Harper, R., Bretag, T. & Rundle, K. (2021). Detecting contract cheating: examining the role of assessment type. *Higher Education Research and Development*, 40(2), 263-278. https://doi.org/10.1080/07294360.2020.1724899.

Sotiriadou, P., Logan, D., Daly, A. and Guest, R. (2020). The role of authentic assessment to preserve academic integrity and promote skill development and employability. *Studies in Higher Education,* 45(11), 2132-2148. https://doi.org/10.1080/03075079.2019.1582015.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Sustainable and solidary experiences in our center

Luz Marina Andreu Plaza, Isabel Rubio Navarro, José Carbonell Alcañiz, Rafaela Ferrer Márquez. Luz Rueda Pérez, Manuel Hurtado Ferrández

IES El Cabanyal, Valencia, Spain

Abstract

This document presents an exploration of four sustainability-focused projects in education, aligning with the 2030 Agenda for Sustainable Development. The projects, centred on Circular Economy, Solidarity, and Sustainable Fashion, aim to enhance students' understanding of climate mitigation and foster responsible citizenship.

Rooted in key competencies like entrepreneurship and learning to learn, the projects adhere to national and international educational frameworks.

The "Solidarity Wigs" initiative addresses the needs of oncology patients, yielding 30 wigs for economically challenged individuals. The "Sustainable Fashion" project raises awareness of environmentally friendly clothing, aligning with sustainability pillars—planet, people, and profit. Through these projects, the paper demonstrates the transformative power of education in fostering sustainability and ethical reflection, preparing students for 21st-century challenges.

Methodologically, each project involves collaborative student efforts, intertwining various subjects, and promoting experiential learning. The findings highlight the positive impact on students and the broader community, emphasizing the crucial role of education in embedding sustainability into daily practices.

Keywords: Circular economy, solidarity, sustainable fashion

How to cite: Andreu Plaza,L.M.; Rubio Navarro, I.; Carbonell Alcañiz, J.; Ferrer Márquez,R.; Rueda Pérez, L. and Hurtado Ferrández,M. (2024) Sustainable and solidary experiences in our center. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 777-784. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In this paper we would like to present various experiences based on four projects thanks to which we have been able to develop and improve both the teaching/learning processes and the awareness of our students in the practices of sustainability, responsible consumption and solidarity. These are also within the framework of Secondary Education and Vocational Education, in accordance with the objectives of the 2030 Agenda for Sustainable Development and the Recommendations of the Council of the European Union in response to the challenges of the 21st century as well as the need to acquire essential learning for life through key competences. The competences to be worked on are two: entrepreneurial competence and competence in mathematics, science, technology and engineering, as defined in Order ECD/65/2015 of the Ministry of Education and Vocational Training. On the other hand, RD 217/20223, regarding the student's exit profile at the end of basic education, states that students must "develop a responsible attitude based on awareness of environmental degradation (...) based on knowledge of the causes that provoke, aggravate, or improve it, from a systemic perspective, both locally and globally". From this competency perspective, Article 11 estab- lishes that this science competency involves understanding and explaining the natural and social environment, using a set of knowledge and methodologies, including observation and experimentation. In this context, the LOMLOE4 emphasizes, in the preamble, the need for ethical reflection on the relationship between technologies, individuals, the economy, and the environment. In this sense, it also references the principles of the 2030 Agenda for Sus- tainable Development with the introduction of the Sustainable Development Goals.

The presented projects are as follows:

-Solidarity Wigs. Track I (Teaching and learning experiences)

-Sustainable Fashion. Track I (Circular Economy models)

2. Projects

2.1. Project 1: Solidarity Wigs (Teaching and learning experiences)

Objectives: To provide hairdressing services by our students to clients undergoing oncological therapies with limited financial resources. Impact on the centre: Raising awareness about solidarity with oncology patients.

Development: Within the scope of Vocational Training, we have initiated the Solidarity Wigs project, operating within the framework of entrepreneurial competency, recognizing it as an educational plan that identifies social needs and develops creative, innovative, and solidarity-driven solutions. This initiative originated from a joint action called "+Q guapas", promoted by the Personal Image Departments of the Valencian Community in 2021.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The Solidarity Wigs project has significantly contributed to assisting economically challenged oncology patients who could not afford a wig. Our primary goal is to provide wigs free of charge. It is essential to note that the cost of a synthetic wig, the most affordable variety, is at least €1,200, an amount often beyond the reach of many individuals.

The project commences with hair collection, inviting the educational community and all interested individuals to participate in a solidarity hair collection day. The subsequent steps involve selecting and treating the hair before crafting the wig. Hair prostheses and wigs are then created and made available to those in need. The participating students are in their second year of the Higher-Level Vocational Training Course in Styling and Hairdressing Management through the subject "Hairdressing in Special Care". Students are involved in the entire process, from collecting donated hair to delivering the wig. In fact, it is the students who craft the wigs and contours, tailoring them to each patient. Throughout the treatment, oncology patients are informed about the changes that will be made to their appearance.

The project commenced in December 2021, and since then, 18 solidarity wigs have been donated. Currently, we are collaborating with the Spanish Association Against Cancer (AECC) and the Association of Breast Operated Women of Sueca (ADOPS). In 2022, the project received the Educational Innovation Award from the Conselleria d'Educació.

Finally, it is important to underline that our project not only benefits sick people, but also made our students better persons. Taking part in this project allows students to live a vital experience that, as Muhammad Yunus –father of microcredits and Nobel Peace Prize winner in 2006– indicates: has produced in them a positive change in their attitude towards hope and altruistic motivation.

2.2. Project 2. Sustainable fashion (Circular Economy models)

Objectives: This is a project aimed at raising awareness among students about the importance of using sustainable and environmentally friendly clothing. In this regard, the goal is to have students recognize sustainable garments and, at the same time, combat the culture of disposable fashion, and thus promoting responsible consumption.

Development: We have implemented the educational project - Sustainable Fashion - with the purpose of creating awareness and educating our students as (future) responsible consumers who are environmentally conscious. The objective is not only a theoretical learning about the world of sustainable fashion or the promotion of circular economy but to achieve an attitude and a paradigm shift regarding consumption and the textile industry.

It consists of a workshop involving several subjects (personal image, economics) where students from Vocational Training, Secondary and Upper-Secondary Education are put in contact with each other to raise awareness about sustainability.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Sessions: 6 hours will focus on raising awareness about circular economy, 2 hours will cover innovative technologies in this sector, 2 hours will be dedicated to observing practical cases, and finally, two final products will be developed (6 hours):

- Upcycling Workshop with Clothing Recycling

- Second-hand Clothing Flea Market at our school.

Workshop Justification: Our starting point is the premise that currently no teenager lives outside the realm of fashion. Clothing and accessories have historically been elements that represent socioeconomic status and identify individuals. In the case of adolescence, as stated by the pediatric expert in this life stage, José Luis Iglesias Diz (2015) "for teenagers, the type of clothing can mean belonging and interacting or not with a social group. Fashion is one of the characteristic manifestations of consumer society, and being in fashion always generates tranquility." Fashion directly influences the lives of young people, acting as an identity marker, and young people strive to create their identity through their clothing and personal image. In that respect, fashion is a great generator of consumption through the promotion of new designs that each season encourage us to continually renew our clothing. In this sense, fashion reflects today's society. That is, the hedonistic lifestyle that characterizes us, the culture of eventuality and hic et nunc fit perfectly with the functioning of the fashion empire. All of this occurs under the law of obsolescence and the logic of hasty renewal (Lipovetsky, 1987).

Table 1 – Consumer behavior: online purchases by products category (% of individuals)

Categories	Purchases online % individual
Clothes and accesories	40
Tickets for events	27
Films	20
Foods deliveries	17
Cosmetic / beauty	16
Music	16
Sport goods	14
Magazines / newspapers	13
Electronic equipments	10
Bicycles, cars, other vehicles	5

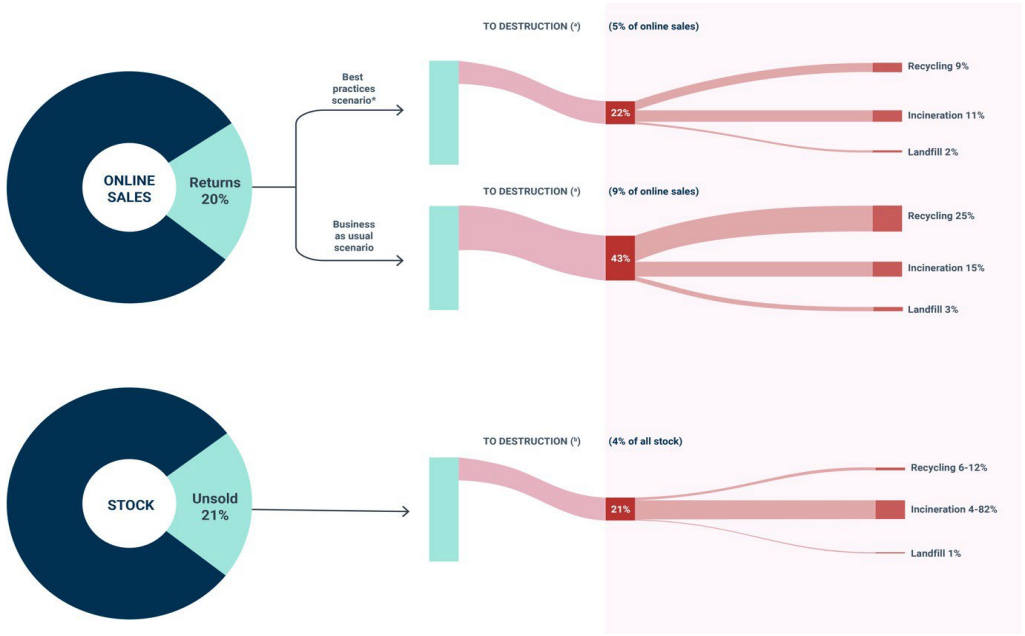
Source: Euratex.eu, own creation.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Based on this foundation, our project has adopted the classic perspective of the three pillars of sustainability – the 3Ps – outlined in the well-known report "Our Common Future", published in 1987 by the United Nations Environment Commission when chaired by Gro Harlem Brundtland. This perspective is based on three fundamental aspects, the famous 3Ps: planet, people, and profit. That is, over the last two decades, the fashion industry has had a great negative impact on climate change and water consumption. According to the European Commission, textile consumption per capita has increased from 8 to 15 kilograms from 2000 to 2023. This significant increase requires deep reflection and intervention from the education field to become aware of its serious effects on our consumer trends.

This overconsumption has many consequences. One of them, as stated by the European Environment Agency, is that between 264,000 and 594,000 tons of textiles are destroyed before use each year. Furthermore, an average of 21% of textile products offered by the market are not sold.

Fig. 1 – Proportion of textile products destroyed



Source: European Environment Agency (2024) The destruction of returned and unsold textiles in Europe's circular economy. https://www.eea.europa.eu/publications/the-destruction-of-returned-and/the- destruction-of-returned-and/download.pdf.static

In this sense, even though fashion prices have decreased in recent years (approximately 30% between 1996 and 2018), average per capita spending has increased by 14%. This lowering of fashion prices, which is an effect of relocation, and the current consumer trend of 'fast fashion' are causing a low rate of use and recycling of clothing. According to the website

BY-NC-SA 2024, Editorial Universitat Politècnica de València

modaes.com, another consequence is that, as consumers, we do not prioritize durability, quality or recyclability.

We will bring down this complex universe that includes the textile industry, the planet, and people to the realm of education and work on it through educational workshops. We have relied on the report "The socioLog.dx experience: a global expert study on sustainable fashion" (Pedersen et al., 2013), which prioritizes aspects such as reducing energy and water usage, decreasing the impact of chemical pollutants, the use of cleaner and environmentally friendly technologies, and ultimately, the production of more durable products. It also references the miserable working conditions in the countries where the main suppliers of the fashion industry are located. On the other hand, we will explain the difference between fabric and fiber, as well as the environmental consequences resulting from their use in industry. We will also address the suitability, facilities, and difficulties related to their recycling. Additionally, we will bring samples of the main materials used to make clothing to the classroom. The aspect related to people has required work with students directly related to the first objective of Project SEED: prepare practitioners and existing professionals with the necessary skills and competencies for the future.

Impact on the school: Raising awareness among students to promote responsible consumption in the field of fashion and aesthetics. Giving a second chance to clothing that is no longer used.

Level: Intermediate and Higher Vocational Training Courses (Personal Image) and Upper-Secondary School (Economy).

Methodology

PROJECT-BASED LEARNING (PBL). A teaching strategy based on an instructional model in which students plan, implement and evaluate projects that have real-world applications beyond the classroom. It develops interdisciplinary and interlevel, long-term, learner-centred teaching activities. Students reflect on the problems they have encountered and what they have learned from the project activities at the end of each evaluation. The outcome is a tangible final product to be shared with the educational, family and local community.

Benefits of PBL:

1. Preparing students for the workplace. Make the connection between school learning and reality.

2. Work on a wide range of extracurricular and interdisciplinary skills and competences. Enable students to see the connections between different disciplines.

3. Work on collaboration, planning, decision making and time management (GANTT chart, brainstorming, Canvas Model to create a business plan...).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4. Increase motivation. The distribution of responsibilities, in addition to a specific time frame, increases motivation and involvement in the project.

5. Collaborative learning that allows students to share ideas, express their own opinions and negotiate solutions. Increasing social and communication skills for problem solving.

6. Providing opportunities for contributions to the school or community. Relationship with private companies and local institutions.

7. Increase self-esteem. Enable students to make use of their individual strengths.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Project 1: Solidarity Wigs

Proyecto +Qguapas bellesa solidària. *Vídeo promoción proyecto*
https://drive.google.com/file/d/1F1A6tXSL9MzaEsVXirc9DVfZqqChnELE/view?usp=sharing
https://gvaedu.sharepoint.com/:v:/r/sites/Section_46013050-C-Erasmus/Documentos%20compartidos/Erasmus/ACTUAL/Cove-Seed/1%20Ponencias/4%20proyectos%20sostenibles%20de%20nuestro%20centro/RAFI/TODO%20COMENZO%20UN%2019%20DE%20OCTUBRE%20DE%202021.mp4?csf=1&web=1&e=BofsNZ

Project 2. Sustainable fashion

Bacigalupo, M., Kampylis, P., Punie, Y., Van den Brande, G. (2016). EntreComp: The Entrepreneurship Competence Framework. Luxembourg: Publication Office of the European Union; EUR 27939 EN

Berman, R. New and smarter textiles race to the future of fashion. Big Think, 04/09/2019. https://bigthink.com/the-present/future-clothes/

Blum, P. (2021). Circular fashion. Blume.

Brundland, GH. (1987). Our common future. Oxford, Oxford University Press.

Collins S. Cheaper method for making woven displays and smart fabrics – of any size or shape.Universidad de Cambridge, 21/04/2023. https://www.cam.ac.uk/stories/smart-textiles

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Comisión Europea (2022). Estrategia para la circularidad y sostenibilidad de los productos textiles. (Comunicación presentada al Parlamento Europeo) https://eur-lex.europa.eu/legal- content/ES/TXT/HTML/?uri=CELEX:52022DC0141#footnote3

Copenhagen Bussines School. https://sustainabilityforschools.org/

Copenhagen Bussines School. Sustainable Fashion https://www.coursera.org/learn/sustainable-fashion/home/welcome

European Environment Agency. https://www.eea.europa.eu/publications/eu-exports-of-used-textiles

Iglesias Diz, J.L. (2015). ¿Cómo influye la moda en el comportamiento de los adolescentes? Temas de revisión. Volumen III.

Kagan, S., Kagan, M. (2015). Cooperative Learning. Kagan Publishing.

Lipovetsky, G. (1987). El imperio de lo efímero. Anagrama

Maldonado Pérez, M. (2008). Aprendizaje basado en proyectos colaborativos. Laurus, Vol. 14, Núm 28, pp.158-180.

Pedersen, ERG., Laursen, LM., Kourula, A. (2013). The socioLox.dx Experience: A global expert study on sustainable fashion. Copenhagen Business School for Coperate Social Responsability (cbsCRS).

Sánchez, J. (2013). Qué dicen los estudios del aprendizaje Basado en Proyectos. Recuperado de www.actualidadpedagogica.com

Tippelt,R., Lindemann,H. (2001). El Método de Proyectos. Consulta en: http://www.halinco.de/html/doces/Met-proy-APREMAT092001.pdf

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Embedding sustainability in a hierarchical Higher Education system

Paul O'Leary[a]

[a]Office of the Registrar, South East Technological University, Ireland

Abstract

In Irish Higher Education, there are a variety of frameworks proposed to confirm the level of achievement (e.g., European Qualifications Framework (EQF), Irish National Framework of Qualifications (NFQ)) and, for some professions or themes, specific outcomes and competencies, such as those related to sustainability, equality, diversity and inclusion, professional bodies, such as Engineers Ireland's accreditation of engineering awards. This work highlights the importance of maintaining public confidence through adherence with the Irish NFQ, while presenting a conceptual plan to integrate outcomes and competencies into course (re-)design, delivery and assessment through a top-down approach for programmes/Schools/Faculties. The paper explains how the balance is arrived at in embedding Sustainability into a programme, using the competency frameworks of the UN SDGs and their related Learning Objectives and GreenComp, the European sustainability competence framework, while also maintaining stakeholder confidence in the award. Maintaining stakeholder confidence means that the work will also take into account the various EQF levels, as some Irish universities are also hierarchical in nature, offering taught programmes from NFQ levels 6 to 9 (equivalent to EQF levels 5 to 7).

Keywords: Qualification Frameworks; Competency frameworks;Accreditation.

How to cite: O'Learya, P. (2024) Embedding sustainability in a hierarchical he system. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 785-792.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Education for Sustainable Development (ESD) is an important tool in the climate change challenge and in assisting graduates to achieve their potential as global citizens. This work is presents an approach to reform a university curriculum to embed sustainability, inspired by the UN SDGs and by the Europe's GreenComp, while at the same time maintaining public confidence in the awards, through the European Qualifications Framework (EQF) and the Irish National Framework of Qualifications (NFQ) and, where appropriate, ongoing professional accreditation, for example with the statutory engineering professional body, Engineers Ireland.

2. Competence and Quality Frameworks

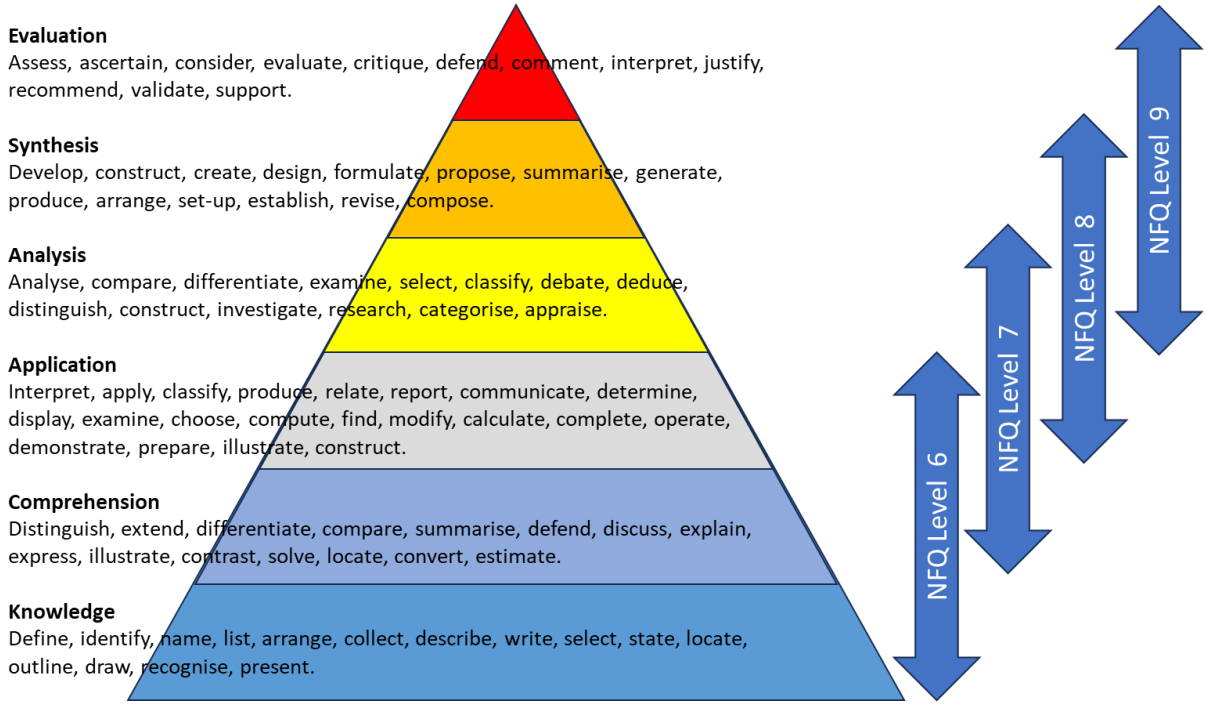
2.1 The EQF and the Irish NFQ

The EQF is an 8-level, learning outcomes-based framework that is not discipline-specific. and usually omit the learning action verb, which can be easily added, but the choice of action verb will depend on the EQF level (European Qualifications Framework, 2017). The EQF is used in EU member states and in a number of other European countries. It is crucial to the mobility success of initiatives such as Erasmus student exchanges and other bilateral or learning progression opportunities because the education in these countries is comparable and can thereby easily be taken from country-to-country. While the 8 levels are important in offering a *scale* of opportunities, this work will focus on EQF levels 5 to 7, where each increasing level indicates an increasing proficiency. Nationally, Ireland implements its own National Framework of Qualifications (NFQ), but this maps smoothly to the EQF, albeit with a slight difference in numbering (the NFQ equivalent levels for this work is levels 6 to 9). Higher Education in Ireland widely deploys constructive alignment where learning and assessment confirm the attainment of module learning outcomes (MLOs), which when selectively combined confirm the achievement of Programme Learning Outcomes (PLOs). Learning Outcomes are primarily drawn from Blooms Cognitive Taxonomy, with Action Verbs broadly selected according to the NFQ level, as is shown in Figure 1. In practice, this means that entry level modules (for example on Year 1 of any programme from NFQ Levels 6-8) draw action verbs from the lower levels, whereas modules taught at postgraduate level (NFQ level 9) typically take their learning outcome action verbs from the higherst three levels.

There are similarities and distinctions between a quality framework and a competency framework, and these will be dealt with later in the paper. Quality frameworks play a key role in confirming public and other stakeholders' confidence in our awards.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 1 – Taxonomy of Action Verbs for Blooms Original Cognitive Domain



Source: Own elaboration

2.2 Competence Frameworks

Competence frameworks collate the key characteristics of the specific role or theme and are widely used to describe the essential skills, knowledge, and attributes that professionals would need to possess to perform effectively. In higher education, they describe the abilities and insights graduates should possess and may even be level specific. For example, in Ireland there is a statutory body for engineers, calle dEngineers Ireland, that provides this information for three distinct levels: Engineering Technician, Associate Engineer and Chartered Engineer. This has benefits to the students, the universities and employers in standardising expectations, improving student employability, shaping continuous professional development and, through the Washington Accord for mutual international recognition of engineering degrees, helps support international mobility, especially outside of Europe (Accords, 1989).

It is worth mentioning that universities often also promote broader qualities for their graduates, called Graduate Attributes (GAs) and that these can crosscut with some of their individual programme's discipline-specific competencies. When this is the case, it can be a symbiotic relationship for the graduates, where both work together to shape desired learning outcomes. By combining broad-based GAs, with discipline-specific competencies, the combination can prepare graduates for success in both their chosen professions and as citizens of an evolving world. However, it must be acknowledged that there is often

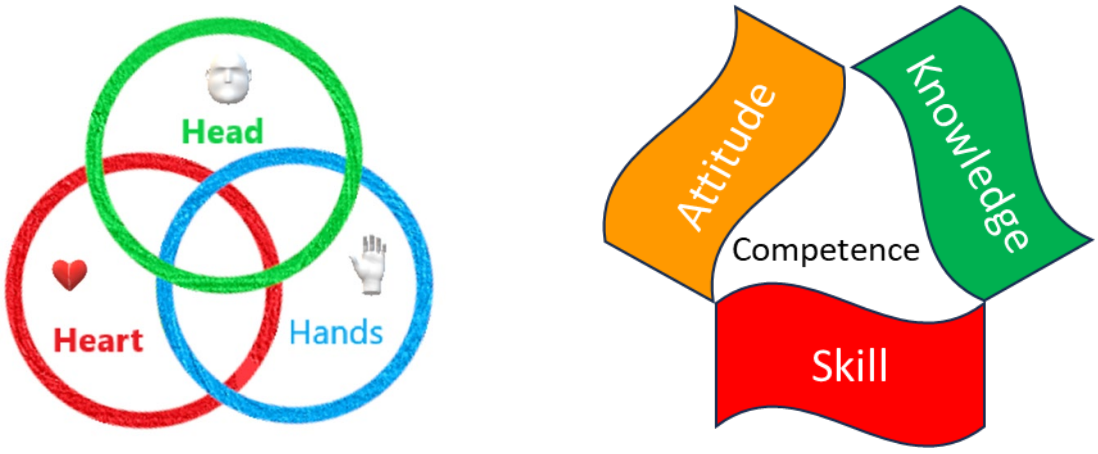
BY-NC-SA 2024, Editorial Universitat Politècnica de València

significant overlap between graduate attributes and competencies. Many graduate attributes (e.g., communication, problem-solving, teamwork) also feature in competence frameworks (e.g. ABET's General Criteria for Baccalaureate Level Engineering Programs, Criterion 3. Student Outcomes) (Criteria for Accrediting Engineering Programs, 2023).

While the NFQ is not explicitly a competency framework, it does feature some common elements in, that both focus on graduate outcomes and defining expected (levels of) knowledge, skills, and behaviours.

In the case of embedding sustainability, it is beneficial for programme teams to adopt a holistic approach, such as presented in GreenComp (GreenComp: the European sustainability competence framework, 2022), the UN SDGs (Education for Sustainable Development Goals Learning Objectives, 2017) or a professional body (Registered professional titles, 2024). Such a holistic approach will be presented in this paper.

Fig. 2 – Transformative Heart-Head-Hands Learning (left) and KSA (right)



Source: Own elaboration

2.4 Learning Outcomes and Competencies

While competencies are attributes of graduates, often a university or professional accrediting body will confirm their attainment, by examining individual module learning outcomes. If a learning outcome describes in a granular manner what a student knows or can do on completion of a module, then the argument goes that the combination of such granular achievements can lead to an acquired competency. This is a distinction between a competency and a learning outcome, being the latter granular and measurable, whereas the attainment of a competency is implicit or indirectly measured. It is important to note that Irish Higher Education has been a strong user of and proponent for Bloom's Cognitive taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). This taxonomy does not easily

2024, Editorial Universitat Politècnica de València BY-NC-SA

lend itself to some approaches to Education for Sustainable Development, such as engaging head, heart and hands (also known as Knowldege-Skills-Attitudes, as shown in Figure 2) of GreenComp (GreenComp: the European sustainability competence framework, 2022), and other comeptence frameworks, where Bloom's two other proposed taxonomies, eventually realised in (Affective (Krathwohl, Bloom, & Masia, 1964).and Psychomotor domains (Dave, 1970)), may have been more appropriate.

2.5 GreenComp and SDGs

There is a National Strategy on Education for Sustainable Development in Ireland, called ESD to 2030, based around the UN's SDGs (Second National Strategy on Education for Sustainable Development in Ireland, 2024). From HE's perspective, a key component of this strategy requires the implementation of UN SDG Target 4.7: "The overall goal of ESD to 2030, is to build a more just and sustainable world through strengthening ESD and contributing to the achievement of the 17 SDGs". Specifically, this has been translated in an associated implementation plan into "integrate and mainstream ESD /SDGs (themes, principles, approaches) into specialist, non-specialist and interdisciplinary higher education courses and programmes" (ESD to 2030: Implementation Plan 2022–2026, 2024). Academic curricular implementation of the SDGs is also covered in UN supporting documentation (Education for Sustainable Development Goals Learning Objectives, 2017).

On the other hand, the European Union has produced a competence framework for ESD, called GreenComp. GreenComp consists of twelve competences, with three in each of four areas: Embodying Sustainability Values, Valuing Sustainability, Promoting Nature and Envisioning Sustainable Futures (GreenComp: the European sustainability competence framework, 2022).

While both approaches are distinct, the Knowledge – Skills – Attitude in GreenComp has some similarities with the Cognitive - Socio-emotional - Behavioural learning objectives in the UN's complementary document (Education for Sustainable Development Goals Learning Objectives, 2017).

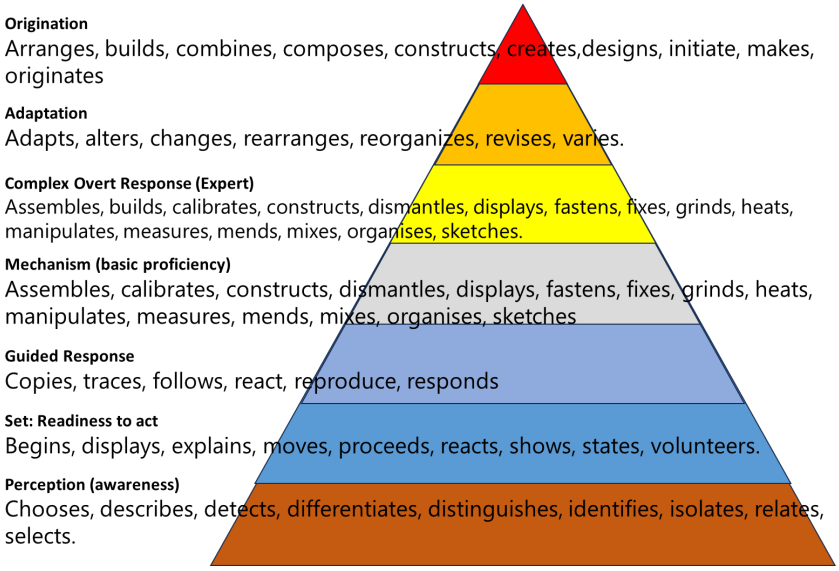
3. Integrating Outcomes and Competencies

This section proposes the approach to be taken by our university's programme teams in maintaining the appropriate programme level (in our case from EQF levels 5 to 7), while embedding sustainability in a holistic manner into their educational offering. Discrete approaches have been proposed to programme teams, to integrate both outcomes and competencies into course design, delivery and assessment. Explicit connections can be made between specific SDG goals and targets and most modules, courses and disciplines. In many

BY-NC-SA 2024, Editorial Universitat Politècnica de València

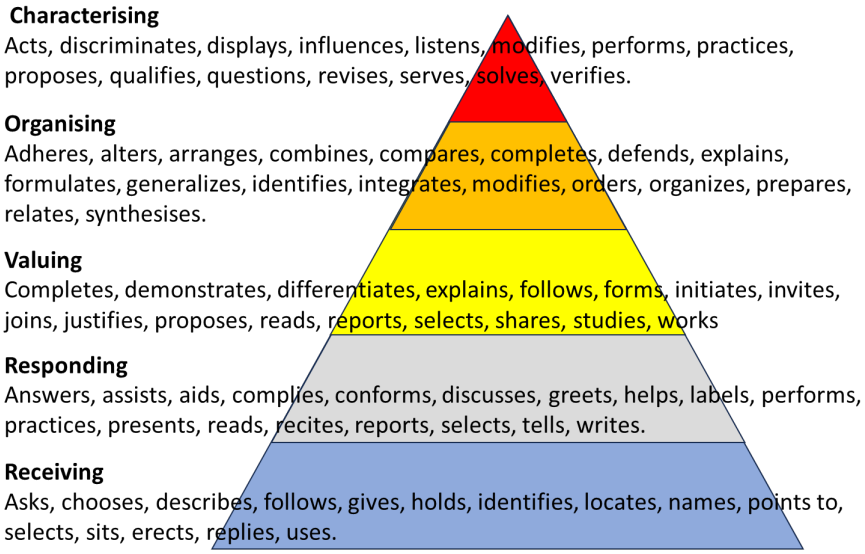
cases, connections between some programmes and the SDGs is not immediately evident and requires guidance or assistance in stimulating debate.

Fig. 3 – Taxonomy of Action Verbs for Dave's Psychomotor Domain



Source: (Arkansas State University, 2024)

Fig. 4 – Taxonomy of Action Verbs for Krathwohl Bloom Masia Affective Domain



Source: (Iowa StateUniversity, 2024)

Guidance to programme teams includes expanding from primarily a cognitive domain and related taxonomy in expressing module and programme learning outcomes, to include the affective and psychomotor domains and related taxonomies, as shown in Figures 3 and 4.

2024, Editorial Universitat Politècnica de València BY-NC-SA

As HE in Ireland may offer EQF levels 5 to 7, the learning outcome action verbs should be selected in a hierarchical manner from the taxonomies shown in Figure 3 and 4, where EQF level 7 verbs are taken from the upper regions and EQF level 5 from the lower regions.

4. Final Comments

This paper is conceptual in nature and presents an approach to implementing competence frameworks, in this case especially a sustainability competence framework, into awards which heretofore were based on quality frameworks, primarily and therefore more reliant on expressing programme and module learning outcomes using Bloom's cognitive domain.

Acknowledgements

The University has been supported in this work through the Strategic Alignment of Teaching and Learning Enhancement Fund, granted by the Irish National Forum for the Enhancement of Teaching and Learning.

Conflicts of interest

The author declares that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Accords. (1989). Retrieved from International Engineering Alliance: https://www.ieagreements.org/accords/washington/

Arkansas State University. (2024, Feb. 12th). Bloom's Revised Taxonomy: Cognitive, Affective, and Psychomotor . Retrieved from Arkansas State University Website: https://www.astate.edu/dotAsset/7a3b152c-b73a-45d6-b8a3-7ecf7f786f6a.pdf

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Vol. Handbook I: Cognitive domain. New York: David McKay Company.

Criteria for Accrediting Engineering Programs. (2023). Retrieved from Accreditation Board for Engineering and Technology, Inc. (ABET): https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/

Dave, R. H. (1970). Psychomotor Levels. In R. J. Armstrong, Developing and Writing Behavioral Objectives. Tucson AZ: Educational Innovators Press.

Education for Sustainable Development Goals Learning Objectives. (2017). Paris: UNESCO.

ESD to 2030: Implementation Plan 2022–2026. (2024). Retrieved from Irish Department of Education: https://www.gov.ie/en/publication/02952d-national-strategy-on-education-for-sustainable-development-in-irelan/#

European Qualifications Framework. (2017). Retrieved from Europass: https://europa.eu/europass/en/europass-tools/european-qualifications-framework

BY-NC-SA 2024, Editorial Universitat Politècnica de València

GreenComp: the European sustainability competence framework. (2022). Retrieved from EU Science Hub: https://joint-research-centre.ec.europa.eu/greencomp-european-sustainability-competence-framework_en

Iowa StateUniversity. (2024, Feb. 19th). Effective Educational Practices. Retrieved from Teaching Resources: https://www.celt.iastate.edu/instructional-strategies/effective-teaching-practices/revised-blooms-taxonomy/

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). Taxonomy of educational objectives: The classification of educational goals. Vol. Handbook II: the affective domain. New York: David McKay Company.

Registered professional titles. (2024). Retrieved from Engineers Ireland: https://www.engineersireland.ie/Professionals/Membership/Registered-professional-titles

Second National Strategy on Education for Sustainable Development in Ireland. (2024). Retrieved from Department of Education: https://www.gov.ie/en/publication/02952d-national-strategy-on-education-for-sustainable-development-in-irelan/

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Emotional Intelligence in Intergenerational Collaboration

Juraj Mikuš[a], Anna Pilková[a], Miloš Mrva[a], Jaroslav Huľvej[a] and Yuliia Fedorova [a,b]

[a]Department of Strategy and Entrepreneurship, Faculty of Management, Comenius University Bratislava, Slovakia

[b]Department of Economics and Management, Ukrainian engineering pedagogics academy, Ukraine

Abstract

The research aims to study the features of Emotional Intelligence (EI) in the case of Ukrainians of different generations (Baby Boomers and Gen Z) and determine ways to develop EI in intergenerational project teams. The methodological basis of the study is the 4-component instrumental model of EI development (4EI Model), which has been adapted to the business environment. With the 4EI Model, we measured the level of EI in business of young people and seniors in Ukraine. The main instrument was the questionnaire "Emotional Intelligence in Business" (40 statements, five-point Likert scale). The findings show that EI in business increases with the age of the respondents as seniors in Ukraine have better scores in all four components of the 4EI Model than young people (they have better developed self-awareness, self-management, social self-awareness and relationship management). The results further show that seniors can be effective leaders in intergenerational project teams. Intergenerational collaboration is, therefore, effective in entrepreneurship. The involvement of seniors in intergenerational collaboration facilitates the open sharing of experience and knowledge, effective communication, and an increase in young people's EI, which generally leads the project team to success. The study demonstrates the practical application of the 4EI Model to study the composition of EI in business. As for further research, this study can be extended to investigate different generations in other European countries.

Keywords: Emotional Intelligence; EI; Intergenerational Collaboration; Emotional Intelligence Profiles.

How to cite: Mikuš, J. ; Pilková, A.; Mrva, M.; Huľvej, J. and Fedorova, Y. (2024) Emotional intelligence in intergenerational collaboration. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 793-801. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

EI is an essential skill in the context of Industry 4.0. This skill cannot be compensated for by artificial intelligence, and at the same time, EI is a link in the mutual understanding of different generations. EI enables the exchange of knowledge and experience, as well as comfortable and constructive communication and collaboration. Employees and entrepreneurs with high EI create added value and additional jobs and thus generate economic and social impact. The development of EI in intergenerational collaboration is a promising direction for research. A review of the literature in databases Scopus and Web of Science revealed a rise in the number of studies on EI in Management, Economics, and Business. During 2019-2023, research on EI in the Management category maintains the third position in the database Web of Science (after the Education and Educational Research category and the Psychology Multidisciplinary category). EI of employees enhances their productivity in professional activities and leads to better economic outcomes (Zhang and Adegbola, 2022; Zhang and Hao, 2022), promotes organisational commitment and job satisfaction, and contributes to workplace health maintenance (Pekkan and Bicer, 2022; Uzunbacak et al., 2022). At the same time, the EI of leaders is a determining factor for team success (Jin et al., 2012; Zhu et al., 2021). EI fosters open knowledge exchange and increases tolerance and initiative, contributing to creative thinking and entrepreneurial development (Lee et al., 2011; Fedorova et al., 2023).

2. Problem Statement

Collaboration between different generations has great potential in the labour market. Five generations are commonly involved in business for the first time in history: Traditionalists (1900–1946), Baby Boomers (1947–1964), Generation X (1965–1980), Generation Y (1981–1995), and Generation Z (1996–Present). This study focuses on older people (Baby Boomer generation) and young people (Gen Z). The terms "Gen Z", "Gen Zers", "the I-Generation", "Gen Tech", "Digital Natives", "New Silent", "iGen", and "Post-Millennial" are some of the terms used to refer to this generation, which was born between 1996 and 2010 (Csobanka, 2016). Generally, in many European countries, two generations, namely Baby Boomers (seniors with extensive experience) and Gen Z (young people who have digital skills and are easily teachable), have an underestimated potential to produce synergies in project teams (Pilková et al., 2022).

We research EI's composition in business using young people and seniors from Ukraine's industrial and educational centre (Kharkiv city). The study's main objective is to develop recommendations for young people (Gen Z) and seniors (Baby Boomers generation) to collaborate in project teams in Ukraine based on assessing EI in business. This paper demonstrates a methodology for developing guidelines for collaboration in multi-generational project teams that can be implemented in different countries.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Analysis of Recent Research and Publications

EI is the capacity to recognise our feelings and those of others, motivate oneself, and effectively manage emotions in oneself and others (Goleman, 1995). Modern approaches to the development of EI have been based on three basic models: non-cognitive theory of EI (Bar-On's, 2000), concepts of emotional and intellectual abilities (Mayer and R. Salovey's, 2000), and mixed views of emotional competence (Goleman, 1995). The Emotional Quotient Inventory (EQ-i), Schutte Self Report-Inventory (SSRI), Mayer-Salovey-Caruso Emotional Intelligence Test 2.0 (MSCEIT 2.0), Trait Meta-Mood Scale (TMMS), Wong and Law's Emotional Intelligence Scale (WLEIS), and Trait Emotional Intelligence Questionnaire (TEIQue) are the instruments that have been reported in the most significant number of studies (Bru-Luna et al., 2021). However, the aforementioned EI assessment methods and tools do not consider the business environment's specifics and are often difficult to apply in practice. In our research on EI in business, we use the 4-component instrumental model of EI development in business (4EI Model), the competencies of which are adapted to the business environment (Mikuš et al., 2022). The 4EI Model is based on the Goleman's mixed model (Goleman, 2017). It is designed to measure the EI of entrepreneurs, business people, managers, and economists. This model has been applied in research on EI in business of young people and seniors in European countries (Mikuš et al., 2023; Fedorova et al., 2023).To measure the components of the 4EI Model, we use a reliable questionnaire "EI in Business" (Lutsenko et al., 2021).

Emotional skills (Rezende and Blackwell, 2019) and emotional competencies (Brière et al., 2014) of team members and project managers lead to the success of project teams. Generation Z multitasks, is well aware of new technologies, and processes information quickly, but often experiences problems with socialisation (Inanc et al., 2022). Studies reveal that teens in the Gen Z generation have different emotional intelligence than previous age groups (Gentina et al., 2018). According to Nagy and Székely (2012), Gen Z is intelligent because they can quickly process much knowledge but cannot process it emotionally. Recent research in Slovakia has shown that older people are more self-aware, and younger people are more empathic (Fedorova et al., 2023). Such studies significantly increase the understanding of the potential contribution of different generations to business cooperation and call for further research on synergies in intergenerational teams. EI is a unique skill that ensures effective cooperation in project teams. As the capacity to build an emotional bond with another person, academics still emphasise empathy as essential to cooperative work. EI is essential in cooperating with employees with different psychological characteristics, visions, experiences, professional skills and work habits (Brechko, 2021). Team members who tend to experience positive emotions tend to demonstrate agile thinking and quick adaptation to new digital technologies. Digital emotional quotient (DEQ) is crucial for agile team members in the digital age (Leeuw and Nazeer, 2023).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Research methodology

The study builds upon the 4EI Model (Mikuš et al., 2022). The 4 EI Model allows us to identify components of EI (Self-Awareness (SA), Self-Management (SM), Social Awareness (SocA), and Relationship Management (RM)) for generations and to form recommendations for the creation of intergenerational project teams. The primary analysis instrument in this study is the "Emotional Intelligence in Business" questionnaire, created following the 4EI Model (Lutsenko et al., 2021). This questionnaire contains 40 statements on a five-point Likert scale (Lutsenko et al., 2021). This paper examines the EI of seniors and young people in Ukraine in 2022–2023. The sample using a non-randomised selection method included 86 older people from the Baby Boomer generation (59 years and older) and 92 young people from Generation Z (aged 19 – 21). Voluntary testing was conducted using Google Forms and the Smart Sender program in Telegram messenger.

5. Results

This research, conducted with the help of the "Emotional Intelligence in Business" questionnaire, allowed us to obtain average values of four components of EI for elderly and young people in Ukraine. According to the 4EI Model, the results from 0–3 are a low level (LL), from 3 to 7 is an average level (AL), and from 7 to 10 is a high level (HL) of the given component. The results shown in Table 1 demonstrate high values of all four components of the EI for both age generations under study (SA, SM, SocA, and RM).

Table 1 – Average value of 4 EI components of seniors and young people in Ukraine

Generation	Self-Awareness (SA)	Self-Management (SM)	Social Awareness (SocA)	Relationship Management (RM)
Young people (Gen Z)	7,76	7,20	7,61	6,14
Seniors (Baby Boomer)	8,28	7,27	8,31	6,90

Source: Own elaboration

All four components of EI are more developed for seniors than young people. The present study confirms that EI in business increases with the age of respondents, which demonstrates the importance of including seniors in project teams. In this sense, seniors will successfully create a healthy working atmosphere, preserve the corporate culture, and facilitate the exchange of knowledge and experience. Young people in a modern project team are undoubtedly more competent and experienced in digital technologies. However, older people from the Baby Boomer generation can share their experience in entrepreneurship and business and contribute to team building. In this way, seniors are more likely to be better

2024, Editorial Universitat Politècnica de València BY-NC-SA

managers and leaders in project teams because of their higher EI. Analyses of variance and t-tests are shown in Table 2.

Table 2 – Analyses of variance and t-tests

	*SA_y**	*SA_s***	*SM_ y**	*SM_ s***	*SocA_ y**	*SocA_ s***	*RM_ y**	*RM_ s***
F-Test Two-Sample for Variances								
Mean	7,7636	8,2791	7,2038	7,2733	7,6141	8,3081	6,1440	6,9041
Variance	0,9332	0,7168	1,6798	0,8597	1,3234	0,9775	2,2256	1,3326
Observations	92	86	92	86	92	86	92	86
df	91	85	91	85	91	85	91	85
F	1,3019		1,9539		1,3539		1,6701	
P(F<=f) one-tail	0,1099		0,0010		0,0795		0,0088	
F Critical one-tail	1,4248		1,4248		1,4248		1,4248	
t-Test	Two-Sample Assuming Equal Variances		Two-Sample Assuming Unequal Variances		Two-Sample Assuming Equal Variances		Two-Sample Assuming Unequal Variances	
Mean	7,7636	8,2791	7,2038	7,2733	7,6141	8,3081	6,1440	6,9041
Variance	0,9332	0,7168	1,6798	0,8597	1,3234	0,9775	2,2256	1,3326
Observations	92	86	92	86	92	86	92	86
Pooled Variance	0,8287				1,1563			
Hypothesised Mean Difference	0		0		0		0	
df	176		165		176		170	
t Stat	-3,7753		-0,4132		-4,3029		-3,8152	
P(T<=t) one-tail	0,0001		0,3400		0,0000		0,0001	
t Critical one-tail	1,6536		1,6541		1,6536		1,6539	
P(T<=t) two-tail	0,0002		0,6800		0,0000		0,0002	
t Critical two-tail	1,9735		1,9744		1,9735		1,9740	

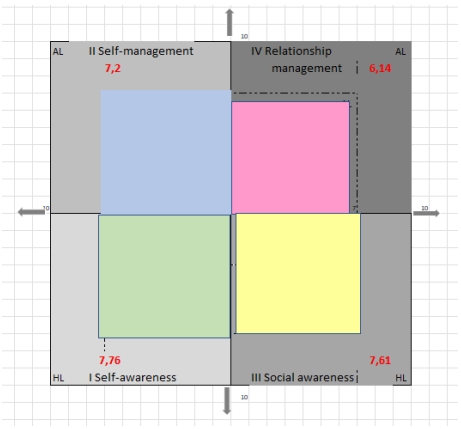
y - Young people (Gen Z) , s** - Seniors (Baby Boomer)*

Source: Own elaboration

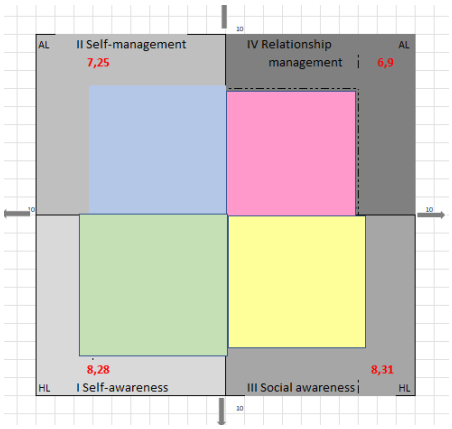
Based on the analysis presented in the table 2, it is evident that the mean values pertaining to various components of EI are notably higher among seniors in comparison to young individuals. Specifically, across all observed EI components, seniors consistently exhibit higher mean values. However, upon utilizing t-tests, a nuanced revelation emerges. While the component of Self-Management does not demonstrate a statistically significant variance between the two studied generations, the remaining components exhibit discernible differences. This finding underscores the relevance of investigating generational disparities in EI, highlighting substantive distinctions between different age cohorts. The Average EI profile of Ukrainian young people and seniors is shown in Figure 1.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – Average EI profile of Ukrainian young people and seniors



Young people (Gen Z)
{7,76^{SA} 7,20^{SM} 7,61^{SocA} 6,14^{RM}} {HL^{SA} HL^{SM} HL^{SocA} AL^{RM}}



Seniors (Baby Boomers)
{8,28^{SA} 7,25^{SM} 8,31^{SocA} 6,90^{RM}} {HL^{SA} HL^{SM} HL^{SocA} AL^{RM}}

Source: Own elaboration

The development of EI in Intergenerational Collaboration is a promising direction in education. It aligns with the Sustainable Development Goals established by the United Nations: good health, well-being, and quality education (United Nations, 2015).

6. Conclusions

This study emphasises the importance of developing EI for Intergenerational Collaboration. Based on the "Emotional Intelligence in Business" questionnaire, EI profiles of different generations (baby boomers and generation Z) were constructed. The results confirmed that EI in business increases with the age of respondents. Representatives of the baby boomer generation achieved better results in all four components of the 4EI Model (self-awareness, self-management, social awareness and relationship management). It is important to emphasise that baby boomers can effectively lead intergenerational project teams. They can share experiences and knowledge, have practical communication skills, and be good mentors for the younger generation. The study's practical significance is in examining how the EI profiles of Ukrainians' different generations can be composed. The research that was conducted can be expanded into other European countries. The study is not without limitations. The research was conducted in an unstable and challenging time for Ukraine when Ukrainians are experiencing high emotional stresses (Mikuš et al., 2023; Fedorova et al., 2023). At the same time, the scope of the research should be expanded further to include more students and seniors in Ukraine. The outcomes of intergenerational team cooperation built from EI profiles are potential areas for further research.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Acknowledgements

This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V01-00055; and the Slovak Research and Development Agency under Grant APVV-19-0581.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

Bar-On, R. (2000). Emotional and social intelligence: Insights from the Emotional Quotient Inventory. In R. Bar-On & J. D. A. Parker (Eds.), *The handbook of emotional intelligence: Theory, development, assessment, and application at home, school, and in the workplace* (pp. 363–388). Jossey-Bass.

Brečko, D. (2021). Intergenerational cooperation and stereotypes in relation to age in the working environment. *Changing Societies & Personalities*, *5*(1), 103–125. https://doi.org/10.15826/csp.2021.5.1.124

Brière,S., Proulx, D., Flores O.N & Laporte M. (2015). Competencies of project managers in international NGOs: Perceptions of practitioners. *International Journal of Project Management,* 33(1), 116-125. https://doi.org/10.1016/j.ijproman.2014.04.010.

Bru-Luna, L. M., Martí-Vilar, M., Merino-Soto, C., & Cervera-Santiago, J. L. (2021). Emotional Intelligence Measures: A Systematic Review. *Healthcare*, *9*(12), Article 12. https://doi.org/10.3390/healthcare9121696

Csobanka,Z.(2016).The Z Generation. Acta Educationis Generalis,6(2) 63-76. https://doi.org/10.1515/atd-2016-0012

Fedorova, Y., Pilková, A., Mikuš, J., Munk, M., & Rehák, J. (2023). Emotional intelligence profiles and intergenerational collaboration in business. Journal of Business Economics and Management, 24(4), 797–817. https://doi.org/10.3846/jbem.2023.20280

Gentina, E., Shrum, L. J., Lowrey, T. M., Vitell, S. J., & Rose, G. M. (2018). An integrative model of the influence of parental and peer support on consumer ethical beliefs: The mediating role of self-esteem, power, and materialism. *Journal of Business Ethics, 150*(4), 1173–1186. https://doi.org/10.1007/s10551-016-3137-3

Goleman, D. (1995). *Emotional intelligence*. Bantam Books.

Goleman, D. (2017). What makes a leader. Harvard Business Review Classics, Harvard Business Pss.Jin, Z., Lukachin, C., Gopalan, A., & Sun, W. (2012). Correlation between SCIAMACHY, MODIS, and CERES reflectance measurements: Implications for CLARREO. *Journal of Geophysical Research*, *117*(D5), Article D05114. https://doi.org/10.1029/2011JD017051

Inanc, E. E., Aydoğmuş, C., Metin Camgöz, S., Ozdilek, E. (2022). For Generation Z: What Is the Underlying Reason Between Emotional Intelligence and Depression Relationship?.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Sosyoekonomi, 30(53), 27-48. https://doi.org/10.17233/sosyoekonomi.2022.03.02Lee, P. K. C., Cheng, T. C. E., Yeung, A. C. L., & Lai, K. (2011). An empirical study of transformational leadership, team performance and service quality in retail banks. *Omega*, *39*(6), 690–701. https://doi.org/10.1016/j.omega.2011.02.001

Leeuw, R. T. & Nazeer J. (2023). Reciprocal Influence between Digital Emotional Intelligence and Agile Mindset in an Agile Environment. *Administrative Sciences* 13: 228. https://doi.org/10.3390/ admsci13110228

Lutsenko, O., Fedorova, Yu., & Tsokota, V. R. (2021). Emotional intelligence as a general personality self-regulation resource – design of a new questionnaire "Emotional Intelligence in Business". In *Proceedings on Problems of personal resources in educational and professional activities, FOP Brovin O.V., Kharkiv, Ukraine* (pp. 51–55). http://dspace.univer.kharkov.ua/handle/123456789/16260

Mayer, J. D., Caruso, D. R., & Salovey, P. (2000). Models of emotional intelligence. In R. Sternberg (Ed.), *Handbook of intelligence* (pp. 396–420). Cambridge University Press.

Mikuš, J., Pilková, A., Fedorova, Y., & Btytan, Y. (2022). Model for the emotional intelligence's develop- ment in entrepreneurship. In *The Poprad Economic and Management Forum 2022* (pp. 402–409). VERBUM. https://www.pemf-conference.com/publishing/

Mikuš, J., Pilková, A., Holienka, M., Fedorova, Y. (2023). Emotional Intelligence in the Development of Entrepreneurial Competence. In: *Auer, M.E., Pachatz, W., Rüütmann, T. (eds) Learning in the Age of Digital and Green Transition. ICL 2022. Lecture Notes in Networks and Systems*, vol 634. Springer, Cham. https://doi.org/10.1007/978-3-031-26190-9_11

Nagy, Á., & Székely, L. (2012). The basis and the structure of the tertiarysocialisation field and the "Youth-Affairs" as an autonomous area. ActaTechnologica Dubnicae, 2(2), 1-18 *(8) (PDF) The Z Generation*. Available from: https://www.researchgate.net/publication/307851870_The_Z_Generation

Pekkan, N., & Bicer, M. (2022). Ethical climate's mediating role on the relationship between emotional intelligence and job satisfaction. *Central European Management Journal*, *30*(1), 115–132. https://doi.org/10.7206/cemj.2658-0845.72

Pilková, A., Mikuš, J., Rehák J. & Pšenák P.(2022) Differences and similarities between key drivers of youth and senior starting entrepreneurs in Central and Eastern European countries. *Post-Communist Economies*. 34(8), 1054-1082, . https://doi.org/10.1080/14631377.2022.2079058

Rezende, L.B. &Blackwell, P. Project Management Competency Framework. *Iberoam. J. Proj. Manag.* 2019,10, 34–59.

United Nations. General assembly resolution A/RES/70/1. Transforming our world: the 2030 agenda for sustainable development. Seventieth United Nations general assembly, 25 Sep-tember 2015, New York. (2015). https://en.unesco.org/sustainabledevelopmentgoals, last accessed 2023/5/31.

Uzunbacak, H. H., Erhan, T., & Akcakanat, T. (2022). Emotionally intelligent employees' work out- comes: The mediating role of organisational commitment. *Etikonomi*, *21*(1), 11–40. https://doi.org/10.15408/etk.v21i1.20541

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Zhang, Q., & Hao, S. (2022). Construction project manager's emotional intelligence and team effective- ness: The mediating role of team cohesion and the moderating effect of time. *Frontiers in Psychol- ogy*, *13*. https://doi.org/10.3389/fpsyg.2022.845791

Zhang, W., & Adegbola, O. (2022). Emotional intelligence and public relations: An empirical review. *Public Relations Review*, *43*(3), Article 102199. https://doi.org/10.1016/j.pubrev.2022.102199

Zhu, F., Wang, X., Wang, L., & Yu, M. (2021). Project manager's emotional intelligence and project performance: The mediating role of project commitment. *International journal of project management*, *39*(7), 788–798. https://doi.org/10.1016/j.ijproman.2021.08.002

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Key factors in the responsible consumption behaviour among university students: The case of Universitat Politècnica de València

Mónica Martínez-Gomez[a]; César Berna-Escriche[b]; Eliseo Bustamante García[c]

[a, c] Departamento de Estadística, Investigación Operativa Aplicadas y Calidad, Universitat Politècnica de València, Spain

[b] Departamento de Estadística, Investigación Operativa Aplicadas y Calidad, Universitat Politècnica de València, Spain; Instituto de Ingeniería Energética, Universitat Politècnica de València, , Spain

Abstract

People's lifestyles determine their relationship with the environment, as well as their responsibility in consumption. SDG 12 aims to ensure sustainable consumption and production patterns, starting from the need to halt environmental degradation caused by technological advances made in the last century. The main aim of this research is to develop and validate a model that analyses the key factors that may influence sustainable consumption among university students. A questionnaire was developed based on the bibliographic review conducted, which took into account the main factors identified. The sample consisted of 212 responses from students at the Polytechnic University of Valencia. The methodology used to obtain an index that contributes to the achievement of SDG 12 was Partial Least Square – SEM (PLS-SEM). The results suggest that Sustainable Consumption Habits (SCB) may be affected by factors such as Social Pressure and Environmental Influence. However, the most significant factor affecting is Sustainable Consumption Behaviour (SCB), a construct, latent factor or dimension, which is in turn affected by Market Conditions and Student Information and Education. These variables may also be affected by Government Actions.

Keywords: Suitability Consumption Behaviour; SDG 12 ; Partial Least Squared-SEM (PLS-SEM), University Students.

How to cite: Martínez-Gomez, M.; Berna-Escriche, C. and Bustamante García, E. (2024) Key factors in the responsible consumption behaviour of university students: the case of Universitat Politècnica de València. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 802-809.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Nowadays society is immersed in a consumerist environment dominated by a market that offers a plethora of products packaged in polluting materials such as plastics. In recent decades, a culture of capitalism has emerged that encourages excessive consumption, leading to a range of environmental problems. However, for several years, efforts have been made to analyse these issues in search of solutions to prevent the degradation of our planet. Unfortunately, climate change continues to have a negative impact on our lives.

Starting in the 1970s, there was a growing concern for the environment, nature, pollution and its impact on climate change. In September 2015, the United Nations Assembly approved the 2030 Agenda for Sustainable Development. This agenda establishes a transformative vision towards economic, social and environmental sustainability for the 193 member states of the United Nations that signed it. It serves as a reference guide for the work of the international community until the year 2030.

The 2030 agenda is a plan of action comprising 17 Sustainable Development Goals (SDGs) to be achieved by the same year. It aims to transform our society into a responsible one that benefits both people and the planet.

This work aims to develop a model that analyses the main factors that influencing sustainable consumption among university students. Besides, this student behaviour is a part of all transversal educational curriculum, expressed in some university degrees as a specific subject or a part of it. In addition, this ethical behaviour such as the use of ecological packages leads to a reduction of energy consumption. The concern for responsible and sustainable consumption among students is also the basis for developing an indicator for SDG 12 and assessing it in the Valencian Community.

2. Framework

A Spanish Millennium Ecosystem Assessment (MEA) report titled "Ecosistemas y Biodiversidad de España para el Bienestar Humano" (Spanish National Ecosystem Assessment (2013)), has revealed that climate change has caused alterations in ecosystems, leading to a reduction in the diversity of fauna and flora. Environmental impact is defined by two areas: the business sector and the individual behaviour. The business sector plays a significant role in raising awareness of the climate situation. This study focuses on the individual sector, a common but multidimensional topic that is difficult to measure. In this vein, to promote the use of sustainable materials in products and encourage a circular economy, the 7/2022 regulation on waste and contaminated soils was implemented on 1 January 2023. This regulation imposes a special tax on non-reusable plastic packaging.

However, when it comes to individual consumption, there are no studies that can precisely measure the methods used or the level of awareness among consumers or households.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Therefore, the only current measure is to encourage people through marketing campaigns to recycle and avoid purchasing products made of non-recyclable materials.

People's lifestyles determine their relationship with the environment and their responsibility in consumption. This is influenced by their mindset, social environment, and daily habits. There is a growing interest in sustainable living, as evidenced by awareness campaigns and the increasing demand for sustainable products, including food, clothing, electronics, and products that were originally made of plastic. SDG 12 aims to ensure sustainable consumption and production patterns. It starts from the need to reduce environmental degradation caused by technological advances made in the last century. While these developments have made our lives easier in many respects, they are rapidly consuming the planet's natural resources and endangering our future development. Impacts experienced include accelerated climate change, reduction in green and aquatic areas and degradation of fertile land.

While the 2030 Agenda provides targets and indicators to measure its achievement, assessing the contribution of individual households or consumers remains a significant challenge. The closest approximation is found in indicator 12.5.1."National recycling rate, in tonnes of recycled material", and it is incomplete as it fails to consider relevant information and factors that could affect the accuracy of the indicator.

Despite various actions being taken to ensure sustainable consumption, there is still a significant gap. Therefore, the purpose of this research is to address this issue.

3. Objectives

This research aims to propose and validate a theoretical model that can identify the determining factors of responsible consumption among university students in the Valencian Community.

The following specific objectives are derived from this general objective:

- To determine the extent to which social pressure influences sustainable consumption habits.

- To determine the extent to which market conditions and received information or education influence sustainable consumption habits.

- To test whether government actions have an impact on sustainable consumption behaviour.

- To examine the relationship between sustainable consumption behaviour and sustainable consumption habits.

- To measure the reduction in energy consumption through these ethical procedures of the students.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- To evaluate this contribution of the behaviour of students to achieve some educational competences as a part of the transversal curriculum.

4. Methodology

A survey was developed using Forms Office 365 for students aged between 18 and 35 at the University to respond to questions related to their consumption habits. The survey considered different factors measured with items on a Likert scale from 1 to 5, where 1 is "I do not agree at all" and 5 is "I totally agree". The survey aimed to gather information on students' consumption habits, their awareness of the sustainability of their purchases, and the influence of the social environment on their decisions. The survey questions were compiled from various articles describing similar procedures to ensure meaningful results (Ashraf, Joarder M, Ratan, 2018; Paço, Shiel, Alves, 2019; Figueroa et al.,2018; Kowalska et al.,2021; Sobhanifard & Griffith, 2018). No changes in content were made. The questionnaire was pretested on 10 master students to assess its acceptability and reviewed by the research team. Minor amendments were made to the text and the questionnaire was then piloted to assess the acceptability of the revised questionnaire with a sample of 25 students at the Polytechnic University of Valencia (UPV). Table 1 shows the dimensions considered in this study together with the questions associated with each of them that have been conveyed to the students. In the present study, we have synthesized the items of the questionnaire according to the greatest repetition in previous questionnaires.

Table 1 – Factor or dimensions and items of the survey

Dimensions	Items of the questionnaire
Sustainable consumption habits	Every day I am careful about the activities I do for the environment. I do concrete activities to protect the environment. I consume local products to support the economy of my area. I consider myself environmentally responsible. I consider the potential environmental impact of my actions before making decisions.
Responsible consumer behaviour	It is important to me that the products I consume do not harm the environment. I am motivated to make changes in my lifestyle to achieve responsible consumption. I care about the waste of our planet's resources. I would describe myself as an environmentally involved and responsible person. I am willing to compromise my comfort to act in an environmentally responsible way. I support brands that produce responsibly. I try to buy products that do not have too much packaging. If possible, I buy products in reusable/recyclable packaging.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

	I have convinced my family and/or friends to buy responsibly. My purchases are influenced by my environmental commitment.
Parent's influence	Someone in my family or friends motivates me to take care of the environment. I have participated as a volunteer in social work related to the environment. I take advantage of the fact that I can now easily get organic or ecological products in supermarkets. Taking care of the environment is a priority in my family. In my regular household, waste is separated for recycling. There is green space in my usual home.
Environmental education	I learn about activities to be more responsible in the use of resources (water, electricity, energy). I am informed about current environmental problems. I am informed about the negative effects of certain products I consume. I pay attention to environmental advertising. I am aware of the advertising behind organic products. The use of green messages in advertising affects my attitude toward such advertising
Social concern	I have felt pressured by my friends to carry out activities for the benefit of the environment. I feel obliged to belong to a group of people involved with the environment.
Market conditions	Organic products give me more confidence than conventional products. I think there are many places where I can find products that are not harmful to the environment.
Government actions	In my city, the government motivates through equality and social justice so that people act responsibly. The government is responsible for doing what is necessary so I can take action for the environment.

Source: Author's ones

A total of 212 responses were collected from students attending various universities in Valencia, with a majority from the Polytechnic University of Valencia. The data was analysed using Partial Least Square Methodology Structural Equations Modelling (PLS-SEM), a multivariate method of structural equation modelling that allows for the analysis of relationships between latent or constructed factors and their indicators, while taking into account measurement error. This approach was first developed by Herman Wold in 1973 and later improved by Ringle, Wende & Will in 2005. PLS-SEM is a statistical analysis method that uses measurement models to build latent factors based on linear compositions of associated measures. The aim of PLS-SEM is to maximise the explained variance, this can be made by

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

the evaluation of the coefficient of determination R^2. Then, the methodology focuses on the maximization of the variance of those latent dependent variables by the latent independent variables (Haenselein & Kaplan, 2004). This method does not require strict parametric assumptions regarding statistical distributions or sample size and is suitable for predictive and non-confirmatory situations.

This methodology involves evaluating both the measurement model, which examines the relationship of each construct with its items, and the structural model, which examines the relationships between constructs. Table 2 shows the statistics that need to be tested in each case.

Table 2 – Statistics to validate measurements and structural models.

Evaluation of measurement models	
Reflective measurement model	***Formative measurement model***
1. *Internal consistency (Cronbach's alpha, composite reliability).* 2. *Convergent validity (Reliability of the indicator and the average variance extracted [AVE]).* $\rho_c = \frac{(\sum_i \lambda_i)^2}{(\sum_i \lambda_i)^2 + \sum_i var(\varepsilon_i)}$ $AVE = \frac{\sum_i \lambda_i^2}{\sum_i \lambda_i^2 + \sum_i var(\varepsilon_i)}$ 3. *Discriminant Validity.*	1. *Convergent validity.* 2. *Collinearity between indicators.* 3. *Significance and relevance of the weights.*
Evaluation of the structural model	
1. *Coefficients of determination (R^2).* 2. *Predictive relevance (Q^2).* 3. *Size and significance of path coefficients.* 4. *Effect sizes (f^2).* 5. *Effect sizes (q^2).*	

Source: Hair et al. (1995, 2014)

5. Results and conclusions

An exploratory analysis was conducted to confirm the main characteristics of the variables. The mean of all items, except the two referring to social pressure, was above 3. This suggests that students are aware of their environmental impact, particularly in their use of resources

BY-NC-SA 2024, Editorial Universitat Politècnica de València

such as water or electricity and are taking action to live more responsibly. Although in this study, we have focused on the private actions of students, there is a great responsibility of state or local governments to promote the consumption of more organic or ecological products. In addition, these products are usually more expensive, and students usually have less purchase level than a worker. In addition, this appropriate student behaviour also leads to a decrease in energy cost. In educational context, this ethical behaviour is a part of all transversal curriculum and the contribution to achieve some educational competences that every professor must evaluate. Of course, in certain university degrees it is explicitly part of the core of their educational curriculum.

A theoretical conceptual model was proposed based on previous studies (Figueroa et al., 2018). The model suggests that market conditions, environmental influence, social pressure, information and education, government actions and sustainable consumption behaviour are possible indicators of sustainable consumption habits. However, the relationships of government actions were not significant, so we propose that this dimension had a positive previous influence on market conditions and on information and education. In the new version of the model, all structural coefficients were significant and all the indexes of both the measurement model and the structural model were significant and exceeded the established threshold. The model explained 0.643 of the variance of the Sustainable Consumption Habits (SCB) through factors such as Social Pressure and Environmental Influence with a structural parameter value of 0.128 and 0.143, but is mainly affected by Sustainable Consumption Behaviour with a structural coefficient value of 0.668, a latent factor in turn conditioned by Market Conditions and by the Information and Education of Students, both variables were affected by possible Government Actions. This model can serve as a reference for establishing actions at both the government and household levels to ensure sustainable consumption habits, contributing to the fulfilment of SDG 12. However, it is important to note that the proposed model is based on a specific sample. To generalize it, we should extend it to samples from other educational levels and universities.

Acknowledgements

This paper has been written with financial support from the Project of the Universitat Politècnica de València (PAID-06-23), "*Support through Data Science, Social Media and Innovation to Enhance Digital Divide and Sustainability with a gender approach: An International Study (DIVIDataSci)*".

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Ashraf, M.A.; Joarder MH, R.; Ratan, S.R.A. (2018). *Consumers' anti-consumption behaviour toward organic food purchase: An analysis using SEM*. Brithish Food Journal, 121, 104–122.

Do Paço, A.; Shiel, C.; Alves, H. (2019) A *new model for testing green consumer behaviou*r. Journal of Cleaner Production, 207, 998–1006.

Geisser, S. (1974). A predictive approach to the random effects model. Biometrika, 61, 101-107.

Hansmann, R.; Baur, I.; Binder, C.R. (2020). I*ncreasing organic food consumption: An integrating model of drivers and barriers*. Journal and Cleaner Production, 275, 123058.

Haenlein, M. & Kaplan, A. M. (2004). A beginners guide to partial least squares analysis. Understanding statistics, 3(4), 283–297.

Hair, J. F.; Anderson, R. E.; Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis.* (Eds.)

Hair, J.; Hult, G.; Ringle, C. & Sarstedt, M. (2014). *A Primer on Partial Least Square Structural Equation Modeling (PLS-SEM)*. Estados Unidos, California: Sage.

Figueroa E.; García J., & Pérez D. (2018). Modelling the Social Factors That Determine Sustainable Consumption Behavior in the Community of Madrid

Kowalska, A.; Ratajczyk, M.; Manning, L.; Bieniek, M. M., & Acik, R. (2021). *Young and Green" a Study of Consumer' Perceptions and Reported Purchasing Behaviour towards Organic Food in Poland and the United Kingdom*. Sustainability 2021, 13, 13022. https://doi.org/10.3390/su132313022

Spanish National Ecosystem Assessment (2013). *Ecosystems and biodiversity for human wellbeing. Synthesis of the key findings.* Biodiversity Foundation of the Spanish Ministry of Agriculture, Food and Environment. Madrid, Spain 90 pp.

Sobhanifard, Y & Griffith, C. (2018). *Hybrid modelling of the consumption of organic foods in Iran using exploratory factor analysis and an artificial neural network.* Brithish Food Journal, 120, 44–58.

Ringle, C. M.; Wende, S., & Becker, J.-M. (2022). *"SmartPLS 4." Oststeinbek: SmartPLS GmbH*

Wold, H. (1973). Nonlinear Iterative Partial Least Squares (NIPALS) Modelling: Some Current Developments. In: PARUCHURI R B T - Multivariate Analysis–III KRISHNAIAH, 383-407. Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-426653-7.50032-6.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Massive Open Online Courses for Sustainable Urban Development: the RES4CITY approach

Álvaro Manso-Burgos[a], Carla Montagud-Montalvá[a], Carlos Vargas-Salgado[a], David Alfonso-Solar[a] and Rafael Royo-Pastor

[a] IIE, Universitat Politècnica de València, Camino de Vera, s/n, 46022 València, Spain

Abstract

The RES4CITY project aims to improve the growth of sustainable renewable energy and fuel technologies in urban areas. This goal will be achieved by implementing a groundbreaking educational program co-designed with stakeholders. The program will aim to develop highly skilled human resources, allowing for results with high replicability across different educational systems. Massive Open Online Courses (MOOCs) offer accessible and flexible learning opportunities to many individuals, making them a viable alternative to traditional education. MOOCs have revolutionised online learning, making it more accessible, flexible, and affordable for individuals seeking to enhance their skills and knowledge. This work explains how the RES4CITY project uses online education and technology by creating 45 MOOCs grouped into eight Micro-programs. This technology reaches and impacts beyond the usual educational boundaries. It allows for knowledge transfer and gives learners the power to become agents of change within their respective urban environments. Furthermore, it provides a platform to showcase innovative approaches, technologies, and solutions in sustainable urban development.

Keywords: online education; urban sustainability; MOOC; climate-neutral cities; decarbonisation strategies.

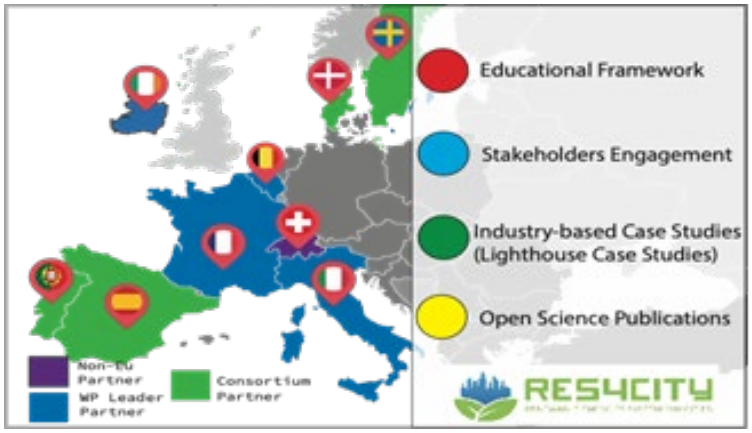
How to cite: Manso-Burgos, A.; Montagud-Montalvá, C.; Vargas-Salgado, C.; Alfonso-Solar, D.and Royo-Pastor, R. (2024) Massive Open Online Courses for Sustainable Urban Development: the RES4CITY approach. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 810-820.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The EU has pushed an ambitious vision of making the EU the first digitally-enabled circular, climate-neutral and sustainable economy by transforming its mobility, energy, construction and production systems (*Horizon Europe - European Commission*, 2023). To reach this objective, we need a concerted action involving various actors (e.g., industries, public institutions, and citizens) with different needs and priorities. Besides, the educational system must be central to this action. Hence, the project RES4CITY aims to enhance the development of sustainable renewables and fuel technologies in cities by promoting sustainability and circularity and by deploying an innovative educational programme, co-designed with stakeholders, to develop highly skilled human capital, to allow for results with high replicability across different educational systems. RES4CITY recognises that particular attention needs to be paid to urban areas since most of the EU population is concentrated in cities where the consumption of resources has been steadily increasing.

Figure 1. RES4CITY partners and main areas of interventions



Source: Own elaboration

The RES4CITY project, founded by the Horizon Europe program, consists of a consortium of 18 partners in 8 EU countries and Switzerland, as depicted in Figure 1. The partners include research-performing organisations of Maynooth University (NUIM), University of Genoa (UNIGE), University of Coimbra (UCOI), Universitat Politècnica de València (UPV), University of Sassari (UNISS), Danish Technical University (DUT), University of Grenoble Alpes (UGA), Institut Polytechnique De Grenoble (UGA), Centre National De La Recherche Scientifique (CNRS) and Halmstad University (HU). RES4CITY also account with non-governmental organisations, namely WiTEC SWEDEN (WTC), Finnovaregio Foundation (FINNOVA), Finnova Spain (FINNOVA ES) and Global Hope Network International (GHNI). Finally, the project also involves the small and medium enterprises Artemat srl (ARTEMAT), Three O'clock (3OC), and Tipperary Energy Agency (TIPP). On top of that, the United Nations Institute for Training and Research (UNITAR) is also a partner for international broadcasting.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

RES4CITY operates on five key pillars to advance sustainable solutions in Renewable Energy Sources (RES) and Fuel Technologies (FT). First, the Innovation and Stakeholder Network collaborates with European public and private entities to support the implementation of green technologies in urban areas. Second, through Lighthouse Case Studies, RES4CITY showcases exemplary projects that address challenges related to environmental sustainability, social equality, and technology diffusion. Third, the Educational Framework aims to introduce innovative teaching approaches to sustainable solutions, create study programs, and leverage micro-credentials for training and reskilling on a Massive Open Online Courses platform. Fourth, the Industry-Academia Partnership establishes an ecosystem for collaboration on practical sustainability challenges designed by the lighthouses, the stakeholder network, and international hubs. Lastly, the Exploitation, Dissemination, and Outreach pillar focuses on increasing awareness, engaging postgraduate and professional students, and fostering dialogue through network events to encourage enrollment in RES4CITY courses and acquiring micro-credentials. Overall, RES4CITY's multifaceted approach seeks to drive innovation, education, collaboration, and awareness for the widespread adoption of sustainable energy solutions in urban settings. This report will focus on the Educational Framework and the Massive Open Online Courses programs, even though they cannot be developed outside the rest of the RES4CITY project.

2. Massive Open Online Courses (MOOCs)

In recent years, the popularity of Massive Open Online Courses (MOOCs) has surged, revolutionising the education landscape (Al-Imarah & Shields, 2019). MOOCs have emerged as a viable alternative to traditional education, offering accessible and flexible learning opportunities to many individuals (Babori et al., 2019; Eisenberg & Fischer, 2014). In the context of the RES4CITY project, the Development of MOOCs serves as a strategic initiative to achieve our goals and objectives.

The rise of MOOCs can be attributed to several factors (Kennedy & Laurillard, 2019; Zawacki-Richter et al., 2018). First, the rapid advancements in technology and the widespread availability of the Internet have facilitated the creation and dissemination of online learning platforms. Second, the escalating demand for lifelong learning and the need to acquire new skills in an ever-changing job market has driven the popularity of MOOCs. Additionally, the increasing cost of traditional education has made MOOCs an attractive and cost-effective option for learners worldwide.

MOOCs are online courses available to anyone with an Internet connection, offering a complete course experience for free without any entry qualifications required (Ossiannilsson et al., 2016). Renowned educational institutions, organisations, or individual experts typically offer these courses. MOOCs cover various subjects, including, among others, science,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

humanities, business, and computer science. These courses are delivered through multimedia resources such as video lectures, interactive quizzes, discussion forums, and assignments. MOOCs often have a structured syllabus, and learners can engage with the content at their own pace, usually following a predefined timeline.

MOOCs possess several key characteristics that set them apart from traditional education. First and foremost, they are open to anyone with internet access, eliminating geographical barriers and providing access to education for learners worldwide (Rolfe, 2015). MOOCs also emphasise self-paced learning, allowing participants to study according to their schedules and preferences (Serth et al., 2022). Moreover, MOOCs foster a sense of community through discussion forums and collaborative activities, facilitating peer-to-peer learning and networking opportunities. MOOCs often employ technology-driven learning methods, such as interactive simulations and virtual laboratories, which enhance the learning experience (Fianu et al., 2018). Additionally, the scale and reach of MOOCs surpass those of traditional education, as thousands or even millions of learners can enrol in a single course.

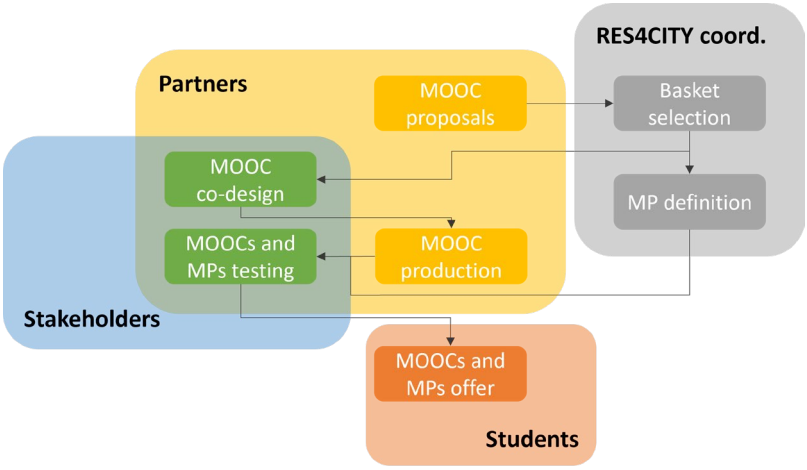
The benefits and convenience of MOOCs are numerous. Firstly, they provide access to high-quality education for individuals who may not have the opportunity to attend prestigious institutions physically (Davis et al., 2017; Otto et al., 2018). Learners can access lectures and course materials from leading experts and institutions worldwide, democratising education (Joshith & Subhash, 2020; Lambert, 2020). Secondly, the flexibility of MOOCs allows learners to balance their studies with work, family commitments, or other responsibilities. This flexibility also enables learners to pursue a diverse range of subjects and explore their interests without the constraints of a rigid curriculum. Lastly, MOOCs often offer a cost-effective alternative to traditional education, with many courses being free or at a significantly lower cost than conventional educational institutions (Laurillard, 2016).

3. Methodology

The RES4CITY project methodology to produce the different courses and educational programs is depicted in Figure 2. The project partners submitted ten MOOC proposals during the inception of this process, offering their specific knowledge and experience. Of those, 45 courses are selected by the RES4CITY coordination organism to be included in the MOOC basket. This collection is divided into eight micro-programs (MPs) offering nuanced and diversified educational paths, as explained in Section 4.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 2. RES4CITY MOOC and MP production flowchart



Source: Own elaboration

During the collaborative co-design phase, project partners and stakeholders work together to define each MOOC's content and structure. This process involves collaborating with the targeted learners and tailoring the course content to meet their unique needs. The collaborative endeavours aim to craft pedagogically compelling and efficacious learning modules.

Stakeholders include representatives of companies in the sector, public administrations, trade unions and training centres, among others. A massive survey was conducted to determine the main topics of interest and the focus on teaching to achieve more effective training for its application in the workplace. With this information, courses and programmes were designed and subsequently revalidated with the stakeholders.

After completing the developmental phase, MOOCs undergo a rigorous testing process, which both project partners and stakeholders oversee. This evaluative phase is critical for refining and optimising MOOCs based on thoughtful feedback and assessment. The overarching objective is to furnish MOOCs that exemplify scholarly excellence and manifest practical efficacy in delivering educational outcomes.

Ultimately, the MOOCs and MPs are open to the public and offered to the students. The courses are provided online and can be undertaken as independent courses or complete programs conveying various courses. All the project partners disseminate the project contents by advertising them on social media, participating in seminars, and collaborating with related projects. Hence, this project achieves its goal of providing open and curated educational programs to educate on the urban energy transition.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

4. MOOCS and Micro-programs of the project

RES4CITY has developed 45 MOOCs to cover all aspects of the energy transition, focusing on urban environments. The complete list of courses is displayed in Table 1. The project's framework includes eight MPs, each comprising some of these courses. All courses and programmes are initially offered in English, although it is envisaged that some partners may translate some courses into their languages to increase local outreach. Next, we will describe each of the MPs.

Table 1. List of MOOCs developed

MOOC ref	Title	MOOC ref	Title
MC01	Enacting a circular economy	MC24	Urban metabolism strategies
MC02	Introduction to sustainable finance	MC25	Digital payments and smart city platform
MC03	Tools, Strategies and Trends in Sustainable Finance	MC26	Understanding critical raw materials
MC04	Investing in sustainability	MC27	How sustainable is your city?
MC05	Climate risk and climate investing	MC28	Sustainable development goals for cities
MC06	Data analytics for the energy sector	MC29	Network industries' regulation and pricing
MC07	Analysis of energy consumption	MC30	Urban renewable energy: decision-making methodologies
MC08	Case studies in energy management	MC31	Energy justice and poverty
MC09	Energy markets	MC32	Social acceptance of technologies
MC10	Conduction heat transfer	MC33	Hydrogen technologies for urban areas
MC11	Energy utilisation and storage	MC34	Decision-making for energy projects under uncertainty
MC12	Thermal simulation of buildings	MC35	Strategic behaviour in energy markets: options and games
MC13	Advanced modelling of buildings and energy systems	MC36	Energy Policy and Flexible Technologies
MC14	Energy strategy and energy transition	MC37	Renewable energy investments
MC15	Energy management and smart communities	MC38	Economics and physics of energy storage
MC16	Energy policy	MC39	Biogas systems for climate transition
MC17	Decarbonisation of thermal energy	MC40	Circular economy for sustainable cities
MC18	Efficient building techniques	MC41	Management of innovation projects
MC19	Energy communities	MC42	Small-scale wind power
MC20	Positive energy districts	MC43	Gender mainstreaming and intersectionality
MC21	Tools for cities' decarbonisation	MC44	Sustainable business models
MC22	Fundamentals of energy system	MC45	Gamification (serious game)
MC23	Introduction to renewable energies		

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

MP1- Sustainable energy technologies and strategies in the urban environment (*Educational STEM)*

This MP provides a comprehensive understanding of sustainable energy systems and strategies for urban environments. The program covers various topics, including fundamentals of energy systems, sustainable finance, renewable energy technologies, data analytics, energy policy, efficient building techniques, tools for city decarbonisation, energy utilisation and storage, and case studies in energy management.

This MP conveys the following MCs: MC22, MC23, MC06, MC18, MC21, MC11, MC08, MC36 and MC45.

MP2- Decarbonisation strategies and social innovation for cities and communities (Educational NON-STEM)

This MP aims to provide an in-depth understanding of the critical concepts and practices related to sustainable energy systems, finance, and urban development. Through this program, participants will learn how to analyse and evaluate the potential of renewable energy sources, propose circular economy solutions, develop sustainable business models, and create strategies for transitioning to a more sustainable energy future.

This MP conveys the following MCs: MC22, MC23, MC02, MC44, MC14, MC32, MC19, MC28, MC40 and MC45.

MP3- Advanced design of sustainable cities (STEM Professional)

This MP provides a comprehensive understanding of the latest trends and techniques in energy systems and sustainable finance. The course covers topics such as decarbonisation of thermal energy, sustainable finance, energy storage, data analytics, circular economy, energy management and smart communities, positive energy districts and analysis of energy consumption.

This MP conveys the following MCs: MC02, MC06, MC15, MC17, MC07, MC13, MC38, MC39, MC42, MC45.

MP4- Business and finance strategies for a sustainable urban transition (NON-STEM Professional)

This MP provides a comprehensive understanding of the managerial strategies related to sustainable energy systems, sustainable finance, and urban development. The curriculum covers topics related to sustainable finance, energy transition, and urban sustainability.

This MP conveys the following MCs: MC23, MC03, MC40, MC44, MC14, MC30, MC41, MC35, MC05 and MC45.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

MP5- Sustainability by design: developing a resilient built environment

This MP focuses on sustainable design strategies for the built environment. The program covers various aspects of sustainable design, including renewable energy, energy-efficient building techniques, thermal simulation, and decarbonisation strategies.

This MP conveys the following MCs: MC18, MC12, MC26, MC24, MC37, MC21, MC13, MC33, MC20 and MC45.

MP6- Innovation in the urban energy sector: strategies and management

This MP focuses on providing a comprehensive understanding of the strategies, analytical tools, and best practices for promoting sustainability and innovation in the energy sector. It provides an extensive and multidisciplinary knowledge of the urban energy sector, including data analytics, sustainable business models, decision-making for energy projects, innovation management, energy strategy, and social aspects of energy technology.

This MP conveys the following MCs: MC23, MC34, MC41, MC32, MC37, MC44, MC31, MC43, MC06 and MC45.

MP7- Sustainable energy solutions for cities: policy and implementation strategies

This MP focuses on providing a comprehensive understanding of the policies, strategies and best practices for promoting sustainable energy solutions in cities. The program covers various topics related to renewable energy, energy strategy, sustainability, digital technology, climate risk and investment, and social considerations.

This MP conveys the following MCs: MC23, MC16, MC14, MC27, MC31, MC32, MC25, MC01, MC44 and MC45.

MP8- Sustainable finance and energy transitions in cities

This MP focuses on providing a comprehensive understanding of the tools, strategies and trends in sustainable finance and how they can be used to finance sustainable transitions in cities. The course covers a wide range of topics, including decision-making for renewable energy, finance tools for sustainability, investment, risk management, energy markets, policy, digital infrastructure, sustainability assessment, and regulation in network industries to support the transition of cities towards sustainability.

This MP conveys the following MCs: MC23, MC30, MC03, MC04, MC29, MC09, MC25, MC27, MC05 and MC45.

5. Conclusions

In conclusion, MOOCs have gained widespread popularity as a flexible and accessible form of education. Their unique characteristics, such as openness, self-paced learning, and community interaction, differentiate them from traditional education models. The

BY-NC-SA 2024, Editorial Universitat Politècnica de València

convenience and benefits of MOOCs, including accessibility, flexibility, and affordability, have opened up new avenues for individuals seeking to expand their knowledge and skills (Cristol, 2020). As the demand for lifelong learning continues to rise, MOOCs are likely to play an increasingly important role in the future of education.

The RES4CITY project leverages the power of technology and online education by offering these MOOCs and MPs to achieve the following:

- Scale and Reach: MOOCs enable us to extend the reach and impact of the RES4CITY project beyond traditional educational boundaries. By providing open access to our educational resources, we can engage with a global audience, including individuals, organisations, and institutions that may not have otherwise had the opportunity to participate in the project.
- Knowledge Transfer: MOOCs facilitate the transfer of knowledge, expertise, and best practices in sustainable urban development. By sharing our insights, research findings, and practical experiences through MOOCs, we contribute to building a collective understanding and capacity for sustainable urban development worldwide.
- Empowerment: Through MOOCs, we empower learners to become agents of change in their respective urban environments. By equipping them with the knowledge, skills, and tools necessary to address sustainability challenges, we foster a sense of agency and empower individuals to positively impact their cities and communities.
- Dissemination of Innovation: MOOCs provide a platform to showcase innovative approaches, technologies, and solutions in sustainable urban development. By highlighting cutting-edge research, case studies, and success stories through our MOOCs, we contribute to the global discourse on sustainable urban development and inspire others to adopt and adapt innovative practices.

Acknowledgements

This work was supported by a grant of the Cátedra de Transición Energética Urbana- funded by Ajuntament de València-Las Naves and Fundació València Clima i Energia; the RES4CITY project, financed by the European Union under Grant Agreement No. 101075582; and the PURPOSED project (PID2021-128822OB-I00) funded by Agencia Estatal de Investigacion of Spain.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Al-Imarah, A. A., & Shields, R. (2019). MOOCs, disruptive innovation and the future of higher education: A conceptual analysis. Innovations in Education and Teaching International, 56(3), 258–269. https://doi.org/10.1080/14703297.2018.1443828

Babori, A., Zaid, A., & Fassi, H. F. (2019). Research on MOOCs in Major Referred Journals: The Role and Place of Content. The International Review of Research in Open and Distributed Learning. https://www.semanticscholar.org/paper/Research-on-MOOCs-in-Major-Referred-Journals%3A-The-Babori-Zaid/9a4d94dbfc7783621af029a6a77d55b8df4a6492

Cristol, D. (2020). Participatory Design and Co-Design—The Case of a MOOC on Public Innovation. https://www.semanticscholar.org/paper/Participatory-Design-and-Co-Design%E2%80%94The-Case-of-a-on-Cristol/3751954593c35ef09239eb7abb8231ef5f8eb370

Davis, D., Jivet, I., Kizilcec, R. F., Chen, G., Hauff, C., & Houben, G.-J. (2017). Follow the successful crowd: Raising MOOC completion rates through social comparison at scale. Proceedings of the Seventh International Learning Analytics & Knowledge Conference, 454–463. https://doi.org/10.1145/3027385.3027411

Eisenberg, M., & Fischer, G. (2014). MOOCs: A Perspective from the Learning Sciences. International Conference of the Learning Sciences. https://www.semanticscholar.org/paper/MOOCs%3A-A-Perspective-from-the-Learning-Sciences-Eisenberg-Fischer/ce3c3c21a013e458f03e07563af1ba4dee710d47?sort=is-influential

Fianu, E., Blewett, C., Ampong, G. O. A., & Ofori, K. S. (2018). Factors Affecting MOOC Usage by Students in Selected Ghanaian Universities. Education Sciences, 8(2), Article 2. https://doi.org/10.3390/educsci8020070

Horizon Europe—European Commission. (2023, December 20). https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Joshith, D. V. P., & Subhash, D. P. D. (2020). Professional Development through Massive Open Online Courses: Awareness and Perception of Secondary School Teachers in Kerala. https://www.semanticscholar.org/paper/Professional-Development-through-Massive-Open-and-Joshith-Subhash/29b7da7a2db9a3e5fc32d79e72ab81eb3c3b1c70

Kennedy, E., & Laurillard, D. (2019). The potential of MOOCs for large-scale teacher professional development in contexts of mass displacement. London Review of Education, 17, 141–158. https://doi.org/10.18546/LRE.17.2.04

Lambert, S. R. (2020). Do MOOCs contribute to student equity and social inclusion? A systematic review 2014–18. Computers & Education, 145, 103693. https://doi.org/10.1016/j.compedu.2019.103693

Laurillard, D. (2016). The educational problem that MOOCs could solve: Professional development for teachers of disadvantaged students. Research in Learning Technology, 24. https://doi.org/10.3402/rlt.v24.29369

Ossiannilsson, E., Altinay, F., & Altinay, Z. (2016). MOOCs as Change Agents to Boost Innovation in Higher Education Learning Arenas. Education Sciences, 6(3), Article 3. https://doi.org/10.3390/educsci6030025

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Otto, D., Bollmann, A., Becker, S., & Sander, K. (2018). It's the learning, stupid! Discussing the role of learning outcomes in MOOCs. Open Learning: The Journal of Open, Distance and e-Learning, 33(3), 203–220. https://doi.org/10.1080/02680513.2018.1486183

Rolfe, V. (2015). A Systematic Review Of The Socio-Ethical Aspects Of Massive Online Open Courses. European Journal of Open, Distance and E-Learning, 18(1), 52–71. https://doi.org/10.1515/eurodl-2015-0004

Serth, S., Staubitz, T., van Elten, M., & Meinel, C. (2022). Measuring the effects of course modularisations in online courses for life-long learners. Frontiers in Education, 7. https://www.frontiersin.org/articles/10.3389/feduc.2022.1008545

Zawacki-Richter, O., Bozkurt, A., Alturki, U., & Aldraiweesh, A. (2018). What Research Says About MOOCs – An Explorative Content Analysis. The International Review of Research in Open and Distributed Learning, 19(1). https://doi.org/10.19173/irrodl.v19i1.3356

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Assessing Post-pandemic Energy Literacy among Children: A Predictive Model based on Current Concerns and Social Learning Theory

Zhichao Lei[a]

[a]Department of Communication, Seoul National University, South Korea

Abstract

The recent war in Ukraine, among other events lately, has fueled market jitters, driving energy costs even higher. Considering the wake of COVID-19 and the continuous energy crisis as well, education for sustainable development and lifestyle on the individual level is required more than ever by future-oriented thinking, which appeals for the combination of financial literacy and energy literacy as a centerpiece in every venue, serving to promote a culture of sustainability. It is imperative for children, in particular, to become energy-literate and adopt sustainable practices in everyday life. Yet, as a precondition for such positive changes, we ought to first locate the starting point for energy education by conducting pre-assessments, which could in turn navigate corresponding interventions. Furthermore, as the market has been taking the brunt of adverse conditions in recent years due to the pandemic and regional conflicts, the variance of children's energy literacy may turn out to be more complicated than ever expected, worth academic attention across national borders. In this concern, the present study proposes a predictive model for post-pandemic energy literacy among children, guided by the Social Learning Theory (SLT). Implications drawn from relevant studies and current concerns regarding energy literacy, as discussed during the development of the model, could hopefully facilitate future educational practices devoted to cultivating the next generation of sustainable energy consumers.

Keywords: energy literacy; assessment; children; social learning theory; sustainable development.

How to cite: Lei, Z. C. (2024) Assessing post-pandemic energy literacy among children: a predictive model based on current concerns and social learning theory. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 821-837. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

As covered by numerous news stories during the COVID-19 pandemic, many people were living in fear, for much was not known about their future lives. Due to the setbacks brought by the pandemic to global economy, workers were laid off, and thousands of households lost income sources and suffered budget constraints; on the other hand, multiple supply shortages, exacerbated by turbulent regional situations like the current Russia-Ukraine war, cause prices of everyday goods and resources to surge. Facing such challenges, people must pay careful attention to family consumption behaviors, including daily energy use, which highlights the significance of mature energy literacy for sustainable development on both the personal and the social level. While the grotesque greed of the fossil fuel industry is still being accused of destroying the planet, the development of energy literacy in the civil sphere has been foregrounded as another imperative requirement, especially for individuals who are suffering from high energy costs. For young age groups who have no formal incomes, such as children and adolescents (not technically distinguished in the current study), their energy literacy could vary depending on many factors. Notably, the notion of children here serves to stress the parent-child relationship in a household, not conceptually excluding the widely accepted adolescent age group (13-17, ranging from grade 7 to grade 12). As they do not earn a living themselves and highly rely on their parents, the development of children's energy literacy could be contingent on parental influences. In the wake of COVID-19, what changes have been brought to children's energy literacy? Entering the post-pandemic age, slash era of great transformation, research working on such questions and exploring possible variables that may predict children's energy literacy is of academic and practical importance, in terms of forming sustainable energy use habits and hopefully putting a stop to the man-made energy crisis in the foreseeable future. In this concern, the present study proposes a predictive model, in hopes of providing practical implications that can help better prepare children with mature energy literacy for adulthood.

2. Current Concerns and Research Questions

Energy depletion has long been a major concern, accompanying the rise of industrialization and consumerism, which requires a transition from fossil fuels to renewable energy sources (Khuc et al., 2023). Such transitions, being mainly persued by governments, aim for low-carbon energy systems and indeed constitute a possible solution to the global energy crisis (Santillán & Cedano, 2023), albeit merely at the macro level. For residential energy consumption, there is a growing need to address the lack of knowledge and awareness regarding household energy consumption and conservation, as they have become highly pressing topics today (Vidimlić, 2023), especially after the pandemic. Affordable, reliable, sustainable, and modern energy consumption has been set as a crucial goal of the UN Agenda 2030, necessitating energy education programs that raise citizens' awareness for more

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

effective energy consumptions (Maurer, Koulouris, & Bogner, 2020). In the long run, changes in the energy systems require an energy-literate citizenship; and energy education programs contribute to the training of energy-literate citizens, who engage in addressing the energy crisis (Santillán & Cedano, 2023). This is where energy literacy comes in, signifying the learning objectives of a learner in an energy education program. Preceding the presentation of research questions, a discussion on current concerns surrounding energy literacy, conceptually and emprically, could provide a comparatively recent illustration of the prerequisites for developing a predictive model of children's energy literacy.

2.1 Conceptualizations of Energy Literacy and related constructs

While its key role in addressing energy crisis has received extensive attention, energy literacy per se remains under-researched (Santillán & Cedano, 2023), giving rise to a series of concerns noted by recent literature and awaiting for further research. In what follows, the critical review on recent literature will cover two prominent topics: a) Energy Literacy and Energy-Literate Citizen; and b) Combination of Energy Literacy, Financial Literacy, and Environmental Literacy. In light of the assortment of relevant works (not necessarily focusing on energy literacy), definitional disputes could arise across individual studies, virtually ruling out a comprehensive and detailed conceptualization of energy literacy. Yet, it is possible to clarify energy literacy without hammering out a sharp-edged definition or settling border disputes with related constructs. Such a clarification can be obtained by focusing on the shared features and broad consensus among extant conceptualizations. Thus, only by sketching the main lines of conceptual work can we summarize the key takeaways for operationalizing the concept of energy literacy in the present study.

Energy literacy could refer to an iteration of literacy relevant to energy (Brychkov et al., 2023), if painted in broad strokes. Building off the fuzzy version, scholars tend to define energy literacy in various manners that suit the interests of their studies. While some seek to simply highlight the purpose of building awareness of wise energy use (Hasanah et al., 2023), in most cases, energy literacy is approached as a combination of awareness, knowledge, and capacities. Santillán and Cedano (2023) propose to interpret energy literacy as the understanding of how energy is generated, transported, stored, distributed, and used; awareness about its environmental and social impacts; and the knowledge to use it efficiently. But such definitions could be accused of only focusing on the cognitive dimension, whereas a body of research has emphasized the positive changes at the behavioral level, like sustainable energy use habit, as the ultimate outcome of exposure to energy-related knowledge (Khuc et al., 2023). In this concern, energy literacy should be examined on the cognitive, affective, and behavioral level, with the introduction of measurements for putative energy-saving effectiveness (Keller et al., 2022). Likewise, Białynicki-Birula and colleagues (2022) investigated multiple aspects of energy literacy such as knowledge, behavior,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

attitudes, and self-efficacy, in efforts to determine what affects them. As for the outcomes of energy literacy projects, or energy education programs, their effectiveness in inspiring positive behavioral changes should be evaluated (Hasanah et al., 2023). In light of these multiple aspects, one recurring theme in the theorization of energy literacy is concretized as the categorization of this compound literacy. Therefore, a functional typology will be proposed later for the model construction.

Bearing such composite conceptualizations in mind, the energy literacy scholarship so far has conducted evaluations among different groups and contributed to the construction, application, and evaluation of tools for improving energy literacy (Santillán & Cedano, 2023). Recently, Hasanah and colleagues (2023) conducted a systematic review of various energy literacy studies in the period 2010–2021. They found that most energy literacy programs during the decade were carried out in a comprehensive, integrated manner, engaged schools, households, and communities, and involved a wide range of stakeholders (Hasanah et al., 2023). While school-based energy literacy programs are specialized in assessments on the cognitive dimension of energy literacy among teenage students (for example, see Sedlbauer et al., 2023), it is noteworthy that a group of scholars investigated the cases of vulnerable groups, such as households including a member with a disability (e.g., children with Autism Spectrum Disorders; see Frączek et al., 2022). In other cases, energy literacy might be discussed in a distinctive manner, considering the needs of expertise and professionalism. For instance, in engineering education, energy concepts could be divided by disciplinary boundary lines, thereby delineating a systematic and multidisciplinary framework of energy literacy. Yet, energy education, underlined here as one of the ways to make society more aware and active about taking actions towards rational energy use (Dias et al., 2021), should aim for the cultivation of an energy-literate citizenship. Therefore, energy literacy, highlighted here as the scope of learning objectives for energy education programs, does not require, yet not object, in-depth contents pursued by energy expertise. In short, most of ongoing discourses surrounding energy literacy shed light on the importance of an energy-literate citizenship, as it depends on the whole society to successfully communicate the significance of a global energy transition toward carbon-free energy sources and to increase civic participation in this transformative process (Kellberg et al., 2023).

Aside from energy crisis, another threat faced by human society is climate change, followed by a spectrum of consequential issues including the pandemic arguably, which also underlines the need for reducing energy waste (Pearce et al., 2020). Generally, the climate crisis has necessitated immediate and sustained efforts to promote energy literacy around the globe (Merritt et al., 2023). Every individual, especially the youth, should be made responsible for confronting and mitigating environmental problems (Khuc et al., 2023), starting with rational energy use to reduce carbon emissions. As energy efficiency through

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

energy saving is a key trend in the modern world (Frączek et al., 2022), energy literacy can be narrowed down to energy curtailment literacy, referring to knowledge, attitudes, and moral reflections related to reducing energy waste by performing curtailment behavior (Pearce et al., 2020). From this perspective, environmental literacy is believed to be correlated to energy literacy, related to but not limited by curtailment, covering electricity production, energy consumption, and their consequences. According to Motevalli and colleagues (2022), some studies examined environmental literacy with energy literacy and ocean literacy.

Similarly, since energy literacy also has consequences for one's economic behaviors (Blasch et al., 2021), energy awareness should be combined with financial awareness (Frączek et al., 2022), implying the necessity of bridging financial literacy and energy literacy in educational endeavors. As early as, maybe, ever since the global financial crisis of 2008, many households have struggled to achieve economic stability, requiring a sustainable strategy for household energy behaviors. Some scholars have proposed the concept of "energy-related financial literacy", working to determine the role of energy literacy and financial literacy in energy-related economic decision making (Blasch et al., 2021). In practice, evidence has been found that education could help save money, resources, and, most important, the climate (Keller et al., 2022). Thus, while the present study tends to mostly foreground energy literacy and energy education, education for sustainable development, or ESD, shall be emphasized as a combination of programs for energy literacy, financial literacy, and environmental literacy – or to put them together, scientific literacy for sustainable development. Energy education constitutes an essential part of ESD, as it aims for "overcoming discontinuities between proconservation thinking and actions leaning towards the efficient use of energy, thus sophisticating the individual's scientific literacy and assigning meaning and tangibility to a concept as abstract as energy" (p.4; Dias et al., 2021). In this view, the role of education for sustainable development merits wide attention, transcending a single literacy and encompassing a wide range of constructs across contexts.

2.2 Energy Education and Education during the COVID-19 period

The overall practices of energy education in a country could play a significant role in achieving an energy-literate citizenship for sustainable development. Since it is commonly the aim of an energy education program, we must understand what the term energy-literate citizenship means as the learning objective of such programs. In daily life, an energy-literate citizen is supposed to dial down thermostats, choose green energy appliances, engage in water recycling, drive at slower speeds, and share rides voluntarily, to list but a few. Such behavioral aspects of energy-literate citizenship can be said to be among the ultimate outcomes intended by energy education. Energy education per se has also become an object of study, as a body of research underscores its importance while looking at its insertion into the educational system (Dias et al., 2021). ESD, or education for sustainable development,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

incorporating energy education, has been integrated and emphasized in school curricula across national and cultural contexts (Motevalli et al., 2022). In service of navigating individuals to lead a sustainable life, educational facilities launched education programs targeting students' energy literacy, financial literacy, and environmental literacy. Through such programs, science literacy for sustainability can be boosted among students and play a critical part in raising future citizens who commit to climate change mitigation by reducing daily household energy use (Aruta, 2023). Evidence indicates that school-based energy education programs can improve children's energy knowledge and attitudes. After energy education was introduced into institutions like elementary schools and universities in the early 1990s (Dias et al., 2021), the past few decades of educational efforts, centering schools as the main stage, could earn a remark of "so far so good" in general. For example, Keller and colleagues (2022) conducted a survey on 6,000 primary and secondary school students. About three-quarters of participants reported that they would positively change their energy consumption behaviors in the future after an energy workshop participation (Keller et al., 2022). However, over-optimism is not allowed. The reason could be, for instance, some substantial topics remain underrepresented in energy education. Sedlbauer and colleagues (2023) note that students perform unsatisfactory on several key points important for their understanding of generation, transformation and collateral impacts of energy, which might be widespread in the active knowedge of young people.

Back in the Covid-19 period, most school-based educational practices came to a halt, pushing educators into looking out for other educational opportunities outside schools and classrooms. Vidimlić (2023) highlights the potential of educational games in fostering energy literacy and shaping personal energy consumption habits, suggesting that future research should explore the combination of digital and physical components in serious games to optimize educational impact and advance energy literacy initiatives. Likewise, Merritt and colleagues (2023) exemplify how video-based discussion can be utilized to create more equitable and culturally responsive online learning environments for energy literacy programs, showcasing an alternative for energy education during social distancing. In general, beyond typical educational facilities, the impacts that might be exerted by different socialization agents - parents, peers, media, etc. - upon the development of children's energy literacy have begun to receive academic inspections (Pearce et al., 2020).

Furthermore, when it comes to energy-related financial literacy, in the past decade, attacks have been unleashed against certain programs, accusing them of being ineffective and unjust. Looking at the bigger picture, one might find that socially created poverty, unemployment and economic insecurity require more than such programs (Arthur, 2012). In response to such critiques, educators are encouraged to integrate social justice topics when teaching about energy, bringing more personal relevance to energy education, as it is their

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

responsibility to guide the next generation toward more just and equitable energy systems (Merritt et al., 2023). Besides, literature on the relationship between energy education and energy literacy seems to be relatively limited, appealing for additional inspections to unveil what factors may influence the perceptual and behavioral outcomes of energy education in various learning settings – particularly home, where children spent most time with their parent(s) during the pandemic years, considerably influcing their development of energy literacy. As a starter, shedding light on the association between science literacy and household energy conservation among adolescents, Aruta (2023) discusses the importance of emphasizing environmentalism in science education, parenting, and community programs as a viable and long-term climate change mitigation response.

2.3 Parents' Socio-Economic Status as an antecedent of Children's Energy Literacy

Children are the main beneficiaries of efforts done to ameliorate climate change and energy crisis, yet little is known about their current energy literacy (Pearce et al., 2020), especially considering the latest changes, globally and regionally. While analyses have been conducted accross various stakeholders that might influence the youth, the present study turns to the context of household and the energy literacy of children, specifically. Home, one of the major contexts for children to grow up, accounts for significant energy consumption and can demonstrate different patterns of energy use, having considerable influences on children's energy literacy. Each aspect of a household's energy consumption reflects the financial situation of the household and influences the household budget (Frączek et al, 2022). In the meantime, parents, as socialization agents, could socialize their children into environmentally responsible individuals (Iwaniec & Curdt-Christiansen, 2020). In this sense, to improve children's knowledge, awareness and engagement regarding energy, home should be another center besides educational facilities.

There is a famous saying in China, which goes, in English: "Children from poor families learn about family finance early." It is implied that low socio-economic status (SES hereafter) households are more likely to breed kids with mastery of financing, compared to their high SES counterparts. One assumption being made here is that relatively limited access to living supplies can cultivate children's awareness of the resource paucity because they always lack something in their childhood, which in turn calls for a sense of urgency to save up resources for emergencies. This line of reasoning, lacking solid evidence yet, has been standing for generations, and the rationale beneath its core assumption seems to make perfect sense. In search of empirical and theoretical supports for it, the relationship between parents' SES and children's financial literacy is a question worth study. However, this question seemingly has yet to receive direct answers from previous literature, not to mention the inspection of children's energy-related financial literacy. Even though discussions have been unfolded arround the impacts of personal SES and parental influences on one's energy literacy, the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

possible relationship between parents' SES and children's energy literacy is still an underappreciated topic. Previously, despite ample studies to the contrary, supports were found that one's decision regarding participation in an energy course was largely influenced by their perception and income (Khuc et al., 2023). Likewise, in a China-based study by Iwaniec and Curdt-Christiansen (2020), results show that children's engagement in some aspects of environmental literacy is related to parents' SES; to be more specific, the lower the parents' SES, the higher the children's engagement. Yet little research directly concerns the relationship between parent's SES and children's energy literacy. Furthermore, the degree of the consistency between parents' SES and children's energy literacy could vary depending on a variety of moderating or mediating factors, which might also explain the findings coming out on the opposite of the assumption underneath the Chinese saying . In general, additional research is required to address whether lower parents' SES is associated with higher children's energy literacy, and, if so, under what circumstance(s).

2.4 Other antecedents of Children's Energy Literacy

Parents' SES, though highlighted above, is only illustrative of how children's energy literacy might be formed. Research on various factors influencing children's energy literacy is on the rise, with a large number of possible antecedents being explored. Several factors that have been considered prominent in the prediction of energy literacy will be discussed here. For example, Motevalli and colleagues (2022) found several social and cultural factors contributing to the development of energy literacy, including family cultural background and parental values, school systems, teachers' beliefs, attitudes, and appraisal of students. Frączek and colleagues (2022) seek to determine the association between parental attitudes and awareness of sustainable energy consumption in the perception of young people (13–17 years old) with Autistic Spectrum Disorder, or ASD. They found a relationship between the acceptance attitude of both parents, the autonomy attitude of one parent (the father), and awareness of sustainable energy consumption among young people with ASD (Frączek et al., 2022). Other factors, including gender, going away from home to study, and the experience of energy poverty, were also found significant in determining children's energy literacy (Białynicki-Birula et al., 2022). Some aim to synthesize recent findings, reaching a conclusion on how enculturation, as an overarching construct that contributes to the literacy of the environmental issues and challenges in maintaining sustainable development, can be developed among children through social and cultural factors (Motevalli et al., 2022). Similarly, Hasanah and colleagues (2023) suggest that future energy literacy programs be based on cultural and religious values, as these values bear relevance to the lives of the learners, in instructions at schools, at home, and within communities.

In sum, regarding what may influence children's energy literacy, answers can be found from any pre-examined factors impactful to personal energy literacy. From this perspective,

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

adopting an appropriate and comprehensive theory to approach the development of children's energy literacy constitutes a priority for the current study. Therefore, following the presentation of research questions below, a theoretical framework will be introduced to integrate family-based channels of influencing children's energy literacy.

2.5 Research questions for the ongoing discourse

While jumping between different topics, we have so far provided a cohesive narrative emphasizing the role of assessment on children's energy literacy in our intellectual, scholarly, and pedagogical work for sustainable development. Saving up for emergency, as implied by the Chinese phrase, fails to see the lay of the land about one's energy behaviors. In this study, additional aspects of energy literacy will be considered to clarify the possible structural differences in children's energy literacy. Chances are certain families turn out to stymie, rather than encourage, children's development of energy literacy, implicitly or explicitly. Tapping into recent literature, the present study attempts to address one central question: what we can do to better prepare energy education programs for today's children and the furture generations, particularly in the wake of Covid-19, which has possibly exerted immense impacts upon their family finance and energy literacy. To this end, two research questions are developed as follows, although they cannot be fully addressed in the present paper: Is there any structural difference in energy literacy among children from different SES households ? If so, how could such difference(s) come into being at the family level?

3. Theoretical Framework and Hypotheses

Halfway through this paper, while several topics around energy literacy have been discussed, what is meant to be addressed stays clear. The current study not only serves the interest of stimulating individuals to lead a sustainable life starting from a young age, but also taps the link between energy education, beyond brick-and-mortar classrooms, and children's energy literacy. The Social Learning Theory (SLT) is adopted for approaching some possible family-based predictors of energy literacy among children.

3.1 SLT rationale for the model development

According to Bandura and Walters (1977), the learning of certain social behaviors relies on three regulatory systems: antecedent inducements (stimulus), response feedback influences (reinforcement), and cognitive processes that guide and regulate action (cognitive control). Energy literacy, if understood as one's energy-related behaviors ot decisions guided by energy knowledge to serve certain energy purposes, is also a learned conduct, just like other forms of social behaviors under the influence of the three regulatory systems.

As previously noted, beyond educational facilities, energy education also takes place in family settings, informally and usually without a syllabus, engaging both children and parents

BY-NC-SA 2024, Editorial Universitat Politècnica de València

in household energy issues. The SLT process of children developing energy literacy via the three regulatory systems in a household context can be delineated as follows: a) through observational learning, children develop their energy literacy during their exposure to the parental antecedents (stimulus) - in the present study, narrowed down to parents' discourses and behaviors regarding family energy consumption - and accordingly identify themselves with their parents in terms of SES; b) via SES identification, children acquire different levels of perceived SES and self-efficacy, both of which belong to the cognitive control system, with the latter assumably somewhat indicated by the former; c) as for the reinforcement system, parents' encouragement and discouragement, in response to children's possible discourses and behaviors concerning family energy issues (for example, directly asking about the state of family electricity expenditure), could have influences on both the perceived SES and the self-efficacy of children, which in turn predicts the learning outcomes of energy literacy.

Besides, the threshold-likeness of COVID-19 pandemic has been repeatedly noted in the present study, with indications of its significance in the construction of a post-pandemic predictive model. During the pandemic, while the agencies in charge of energy resource management kept bombarding the public with messages, as always, calling for positive behavioral changes, people themselves, facing the uncertainty inflicted by the pandemic, might adopt behaviors calculated to conserve resources. Individuals who express positive attitudes toward energy conservation may nevertheless need to be induced to act consistently with their attitudes; and the pandemic, as a long-lasting incident, happened to force some households into taking energy-saving actions. Yet, whether such incident-induced changes are persistent remains unclear and should be tested upon entering the post-pandemic age. Seeking to solve such puzzles, a predictive model for post-pandemic energy literacy of children should be constructed, mostly based on a presumed relationship between children's energy literacy and parent's SES. Behind the presumed relationship lies an assumption, which is logically and theoretically well-founded: Parents' SES assumes an important determinant of children's mental states and behaviors, functioning through SLT regulatory systems. It is common knowledge that in the pandemic years, or any other times of emergency, children stay with their parents most of the time, as education or social care institutions are out of service. Hence, parental influences on children may be magnified in such periods, through the SLT mechanisms described before. For a foray into this view, Pearce and colleagues (2020) find that parents appear to have the biggest impact on the formation of children's energy curtailment literacy and are therefore considered as the main socialization agents to children, even overshadowing the influence of media and peers.

3.2 A functional typology of energy literacy

As underscored earlier, the lack of consensus in the conceptualizations of energy literacy has given rise to a chaotic and unsettled situation, in which neither genuine accumulation of

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

results nor confident generalization is possible. Thus, the enterprise of categorizing energy literacy is driven by the search for a set of universal and mutually exclusive functions served by energy literacy, thereby providing a broad, maybe non-exclusive, and promising approach to energy literacy. In this concern, while deferring the task of detailed energy literacy typologies that identify general functional differences, the following discussion lands on a functional trichotomy of energy literacy.

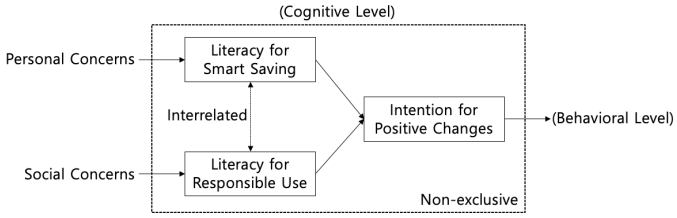
Among all the functional aspects of energy literacy defined by scholars, some aspects are believed to be foundational. Merritt and colleagues (2023) adopted a funds of knowledge (Fok) approach to understanding students' overall sets of abilities and experiences regarding energy, which includes the following content areas: energy sources, energy impacts, agriculture, conservation, energy industry perspectives, and energy consumption. Likewise, an earlier survey was taken to gauge students' interests in energy, existing technical understanding, and energy tendencies (Nelson et al., 2020). Pulling together all these concerns, energy literacy encompasses broad contents that enable people to make appropriate energy-related choices and embrace changes in ways of harnessing and consuming energy (DeWaters & Powers, 2011). Basic energy knowledge, like how to save household energy expenditure, is supposed to be learned by every person before adulthood, for such contents should be understandable to children, in comparison with other relatively sophisticated concepts like carbon footprint, and might have a huge impact on their future energy consumption habits. In this sense, energy literacy for smart saving (out of family financial concerns) and energy literacy for responsible use (based on a sense of social responsibility) are adoptable for structurally approaching children's energy literacy at the conceptual level. Meanwhile, behavioral intention for positive changes - an important predictor of rational energy-related behaviors - should also be assessed as part of children's energy literacy. While energy knowledge can impact one's willingness to act (Kellberg et al., 2023), latest findings also indicate that although young adults are highly concerned about the environment, more work has to be done to turn perceptions into actions (Khuc et al., 2023). In the debate on the link between energy-literate individuals and efficient energy use, the presence of various barriers in taking actions (e.g., lack of time for implementation and prioritization of other needs) is frequently noted (Dias et al., 2021). In light of such barriers, it takes a great amount of time to modify behaviours, which requires not only the lasting exposure of children to energy knowledge, but also the monitoring of their behavioral intention for positive changes. Therefore, a third aspect of energy literacy worth inspection is its intentional facet, bridging pure literacy (knowledge) and actions.

The broad functional distinctions above - a trichotomy, to be precise (see Figure 1) - have been found widely useful, with each category being a commonplace aspect of many energy literacy assessments. Although continuing research may, hopefully, eventuate in a well-

BY-NC-SA 2024, Editorial Universitat Politècnica de València

evidenced set of well-articulated functions of energy literacy on a general level, for now we can simply appreciate the practical value of the trichotomy here in approaching one's energy literacy structurally.

Fig. 1 – Trichotomy of energy literacy on a functional basis



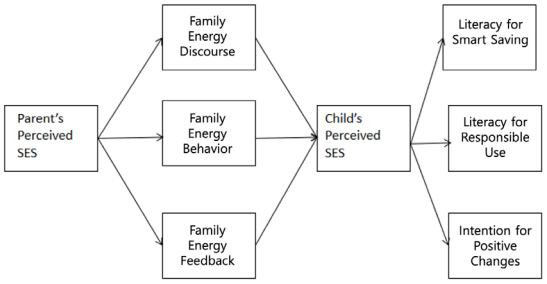
Source: the author

3.3 Impact of SLT variables on Children's Energy Literacy in a hypothetical model

Given a typology of energy literacy, the next question that naturally arises is how SLT variables may influence children's energy literacy. Parents' perceived SES (PP-SES hereafter) is assumed to be a pre-existing factor that influences the three SLT variables noted before. In comparison with one's actual SES, which cannot be scientifically evaluated without financial documents (not easy to acquire), what matters in the present study is one's perceived, self-reported SES. General hypotheses are stated as follows: PP-SES would influence the three SLT variables, Family Energy Discourse & Family Energy Behavior (stimulus), and Family Energy Feedback (reinforcement), which would in turn influence the child's perceived SES (CP-SES hereafter); and CP-SES, working together with self-efficacy as a psychological mediator (cognitive control), would predict energy literacy for Smart Saving, Responsible Use, and behavioral intention for positive changes, in different manners. The specific relations between different variables - positive or negative - could be examined with primary findings of an assessment of children's energy literacy (namely, a test). Since the current study, to a large extent, falls into the category of exploratory research, broadly developed hypotheses should be more acceptable while lacking previous literature to support more detailed constructions. Figure 2 demonstrates the conceptual model of the general hypotheses. In addition, children's grade (1st-12th) and SNS (Social Network Service) use could also influence their energy literacy. Based on the interest of the current study, they can be treated as control variables during the statistical analysis.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 2 – Conceptual Model of the Hypotheses



Source: the author

As a testimony to the model's potential utility, consider the Chinese phrase noted previously and the line of reasoning behind it. However, for an average household, energy performance is an intricate issue driven by complex causality of interconnected and dynamic factors (Brychkov et al., 2023), which is certainly not all covered by the model. The test and application of the predictive model would permit investigators to draw conclusions about the structural variance of children's energy literacy based on family SES. As it is imperative to incorporate social justice as an integral part of energy education, we can learn how such justice concerns might take shape in future educational initiatives, corresponding to the possible structural differences of children's energy literacy implied by the predictive model. The following section is a discussion of how the model can be tested, with recommendations on methods (including instruments for measuring) and a procedure regarding how such an assessment can be conducted.

4. Suggested Procedure and Instruments

The preceding sections have discussed the need for pre-assessments of children's energy literacy and corresponding interventions in energy education programs. This section will provide some details on what might be entailed in the assessment. In what follows, a procedure is described to illustrate how the predictive model can be examined in a study.

Needless to say, it may take a considerable amount of time and resources to administer such a study. First, a 4-item (at least) survey should be crafted to measure PP-SES and three family-based SLT variables. Second, a well-developed energy literacy test can play a prominent part. A possible fit is the work by DeWaters and Powers (2011), a written questionnaire completed by 3,708 secondary students in New York State for measuring their energy literacy. This questionaire covers a spectrum of energy topics and could be adapted in accordance with energy literacy for smart saving, responsible use, and intention for positive changes. Researchers should replace original questions with appropriate, detailed, and easy-to-understand versions, in efforts to preclude as many misunderstandings as possible on the part of children. While baseline descriptions of specific items are available online, the bottom line here is that all statements included in the test should be easy for

BY-NC-SA 2024, Editorial Universitat Politècnica de València

children to understand, such as "the world will eventually run out of old energy sources" rather than "fossil fuels are nonrenewable resources" (the adjective "nonrenewable" may be easy for adults to comprehend but not so much for children), and that the adaptation should be appropriate for gauging the structural state of childrens' energy literacy (a score should be graded on each aspect of the trichotomy). Indeed, substantial efforts and time are required to obtain a sound energy literacy test, which constitutes a deterrent to the assessment of children's energy literacy and the model testing.

With the participation of recruited children accompanied by their parents, the results from the children's test and the parents' survey could help examine whether CC-SES and certain aspect(s) of energy literacy are associated with the three SLT variables, and to what extent PP-SES predicts children's energy literacy via SLT variables. Nonprobability sampling should be adopted to recruit participants for the study. To address the research questions, at least two groups should be set, as low SES versus high SES, according to the self-reported PP-SES. Since the findings should be generalizable to prove or disprove the existence of a social phenomenon that applies to a whole population, the sample size is supposed to be as large as possible. While parents take the 4-item survey noted above, the children are instructed to complete the test on their own. One item could be added to the end of the children's test, inquiring about CP-SES. One thing for sure is, children have limited understanding of some abstract and inevitable energy concepts. Therefore, even with adaptations beforehand, each test question should better be collated with a detailed explanation. Children can also put aside any question(s) that they do not understand.

5. Implications, Limitations, and Prospects

This introductory paper has elucidated the concept of energy literacy with related constructs, sketched the possible relationship between children's energy literacy and parents' SES, and described a procedure for assessing children's energy literacy and testing a predictive model. With the hope that every child could acquire energy literacy in early years during which parents play a significant role, implications drawn from the predictive model could serve educational purposes, helping better the design of energy education programs that engage both parents and children. In the final discussion, implications, limitations, and potential challenges associated with the assessment of post-pandemic children's energy literacy are included, albeit briefly, to provide a balanced and realistic view of the proposed model.

It seems safe to say that we are on the right track by introducing a test instrument to the on-going discourse of post-pandemic children's energy literacy. By doing so, we could obtain data of each participant's performance, as a periodic checkup of children's energy literacy that can reflect their prior knowledge before participating in an energy education program. To better monitor a program's effectiveness, a pre- and post-test design should be utilized to

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

measure a learner's energy literacy regarding knowledge, attitudes/values, and behaviour, as suggested by Maurer and colleagues (2020). Researchers could also employ preliminary findings of children's energy literacy to a subsequent analysis with conceptually or empirically related variables, in search of possible causation or correlation. Policy implications can then be drawn from antecedents of children's energy literacy, once established, for promoting energy transformation,nurturing sustainable cultures, and propelling ESD improvements.

However, at present the research design itself still has a lot to be considered. As for sampling, even though aiming for as many children as possible is admirable in terms of sample size, what often happens in this kind of research is data saturation, which means that at a certain point researchers will be seeing the same thing repeatedly and they can just stop. Therefore, alternatively, a moderate number of participants could be assigned to several separate studies following the same procedure for the test of replicability. Besides, even though more than 3,700 students from New York State participated in the energy literacy test (DeWaters & Powers, 2011), it does not assure that the adapted test qualifies for the assessment of children's energy literacy. There are several threats that may undermine the validity of the test results. For instance, the latent flaws of the US-based test and what could go wrong with such flaws in another cultural or national context should be examined prior to a formal study. More important, the test per se could be an intervention in its own right. While the test results can directly reflect participants' energy literacy to some degree, we would miss out on a wealth of important information when relying on the test alone. We can go one step further and use the results to have children reflect on their current energy literacy. In this concern, pre- and post-test interviews and observation during the test might help capture valuable information (e.g., on-site hesitation when facing certain questions) for follow-up studies. Notably, it would be helpful to sit with the children and have them explain why they give certain answers to certain questions. But the expected huge number of participants may prevent researchers from doing so. Perhaps this can be done with a subset.

Moreover, the trichotomy of energy literacy proposed in this paper could ultimately render the assessment of children's energy literacy narrow and incomplete. Only a preselected set of energy literacy is considered in a reductionist style, while many valuable dimensions elude the investigation. Given that energy literacy could also be approached as, for example, the general ability to understand and effectively use various energy-related skills including energy management, budgeting, etc., smart saving and responsible use merely account for part of it. The importance of the energy transition should also be imparted into children and foster their multifaceted competencies of energy literacy (Kellberg et al., 2023). Therefore, to sufficiently address the core question - whether there is any structural difference in energy literacy among children from different SES households - more aspects of energy literacy, like green energy investment, need to be addressed by future studies, providing

BY-NC-SA 2024, Editorial Universitat Politècnica de València

recommendations on learning interventions to equip future citizens for an evidence-based public debate on the transition to sustainable energy sources (Sedlbauer et al., 2023).

Focusing on children's energy literacy in fast-changing reality after the pandemic, this line of research, as suggested by Frączek and colleagues (2022), should be interdisciplinary and encapsulate scientific domains such as pedagogy, psychology, economics, and so on. It is advisable for future studies to start with the predictive model, picking some aspect(s) of it for validation and elaborating on the dynamics in different traditions. Hopefully, insights into post-pandemic energy literacy among children can be put to use in developing an effective strategy for cultivating the next generation of energy-literate citizens, buttressed by the improvements of physical infrastructure, as well as political and regulatory enablers.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The author declares that he has no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Arthur, C. (2012). Financial literacy education: Neoliberalism, the consumer and the citizen. Brill.

Aruta, J. J. B. R. (2023). Science literacy promotes energy conservation behaviors in Filipino youth via climate change knowledge efficacy: Evidence from PISA 2018. Australian Journal of Environmental Education, 39(1), 55-66.

Bandura, A., & Walters, R. H. (1977). Social learning theory (Vol. 1). Prentice Hall: Englewood cliffs.

Białynicki-Birula, P., Makieła, K., & Mamica, Ł. (2022). Energy Literacy and Its Determinants among Students within the Context of Public Intervention in Poland. Energies 2022, 15, 5368.

Blasch, J., Boogen, N., Daminato, C., & Filippini, M. (2021). Empower the consumer!: energy-related financial literacy and its implications for economic decision making. Economics of Energy & Environmental Policy, 10(2), 149-180.

Brychkov, D., Goggins, G., Doherty, E., Romero, N., Roudil, N., Di Trani, A., ... & Clifford, E. (2023). A systemic framework of energy efficiency in schools: experiences from six European countries. Energy Efficiency, 16(4), 21.

DeWaters, J. E., & Powers, S. E. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. Energy policy, 39(3), 1699-1710.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Dias, R. A., de Paula, M. R., Rizol, P. M. S. R., Matelli, J. A., de Mattos, C. R., & Balestieri, J. A. P. (2021). Energy education: Reflections over the last fifteen years. Renewable and Sustainable Energy Reviews, 141, 110845.

Frączek, B., Gagat-Matuła, A., & Plutecka, K. (2022). Parental Attitudes and Awareness of Sustainable Energy Consumption in the Opinion of Young People with Autistic-Spectrum Disorder (ASD); Implications for the Family Budget. Energies, 15(5), 1730.

Hasanah, A., Sahlani, L., Zuhri, M. T., Kholifah, N., & Nurtanto, M. (2023). A systematic review of energy literacy programs at primary and middle schools. Pegem Journal of Education and Instruction, 13(1), 145-155.

Iwaniec, J., & Curdt-Christiansen, X. L. (2020). Parents as agents: Engaging children in environmental literacy in China. Sustainability, 12(16), 6605.

Kellberg, S., Nordine, J., Keller, M., & Lewalter, D. (2023, March). Fostering students' willingness to act pro-environmentally through an identity-oriented socio-scientific exhibition on the energy transition. In Frontiers in Education (Vol. 8, p. 1081633). Frontiers.

Keller, L., Riede, M., Link, S., Hüfner, K., & Stötter, J. (2022). Can education save money, energy, and the climate?—assessing the potential impacts of climate change education on energy literacy and energy consumption in the light of the EU energy efficiency directive and the Austrian energy efficiency act. Energies, 15(3), 1118.

Khuc, Q. V., Tran, M., Nguyen, T., Thinh, N. A., Dang, T., Tuyen, D. T., ... & Dat, L. Q. (2023). Improving energy literacy to facilitate energy transition and nurture environmental culture in Vietnam. Urban Science, 7(1), 13.

Maurer, M., Koulouris, P., & Bogner, F. X. (2020). Green awareness in action—how energy conservation action forces on environmental knowledge, values and behaviour in adolescents' school life. Sustainability, 12(3), 955.

Merritt, E. G., Weinberg, A. E., & Archambault, L. (2023). Exploring Energy Through the Lens of Equity: Funds of Knowledge Conveyed Through Video-Based Discussion. International Journal of Science and Mathematics Education, 1-24.

Motevalli, S., Saffari, N., Michael, M. T. A., & Abadi, F. H. (2022). Enculturation, Education and Sustainable Development: Understanding the Impact of Culture and Education on Climate Change. International Education Studies, 15(4), 31-41.

Nelson, M., Hoople, G., Chen, D., Mejia, J., & Lord, S. (2020, January). Work-in-Progress: What is Energy? Examining Engineering Students' Conceptions of Energy. In ASEE Annual Conference proceedings.

Pearce, H., Hudders, L., & Van de Sompel, D. (2020). Young energy savers: Exploring the role of parents, peers, media and schools in saving energy among children in Belgium. Energy Research & Social Science, 63, 101392.

Santillán, O. S., & Cedano, K. G. (2023). Energy Literacy: A Systematic Review of the Scientific Literature. Energies, 16(21), 7235.

Sedlbauer, J., Slavík, M., Hejsková, P., & Činčera, J. (2023). Externalities Still Underrated in Energy Education. Available at SSRN 4419497.

Vidimlić, H. (2023). Learning by Gaming : Design and Evaluation of a Serious Game to Increase Energy Literacy (Dissertation, KTH Royal Institute of Technology). Retrieved from https://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-332120

BY-NC-SA 2024, Editorial Universitat Politècnica de València

MiSchoolInTransition: learnings from the adaptation of the EuroNet 50/50 method in educational centres of the city of Valencia (Spain)

Paula Martin[a], Blanca Llavata[a], Paula Martínez[a], Eduardo Amer[a] and Corentin Girard[b]

[a] Imedes - Instituto Mediterráneo para el Desarrollo Sostenible, Spain

[b] Foundation València Climate and Energy, Valencia City Council, Spain

Abstract

The recognition of the necessity for a clean and equitable energy transition is now widespread, and efforts have been undertaken to enhance awareness of resource efficiency, particularly among the younger population. This involves promoting energy-saving habits and behavioral changes to directly reduce energy consumption and facilitate the development of ambitious public climate policies. In this paper, we introduce an innovative adaptation of the Euronet 50/50 method implemented in educational centers in the City of Valencia, Spain, known as the #MiSchoolInTransition program. Initiated by the Municipal Energy Office of Valencia, this service-learning program combines learning with community service. Developed since 2019 by a collaborative team of environmental scientists and educational practitioners from the city's Energy Office, the program aims to support the development of Neighborhood In Transition Projects, aligning with the city's climate neutrality objectives. The paper outlines the adaptation of the methodology for secondary schools, vocational training centers, and adult educational centers in Valencia City. Additionally, it presents the initial quantitative results of projects that have impacted more than 6,000 people since 2020, achieving up to 12,558 kWh in annual energy savings at a high school. These findings underscore the method's substantial potential not only to generate short-term quantitative impacts but also to instigate enduring transformational dynamics within educational communities and beyond.

Keywords: Awareness raising; Service-learning; Euronet 50/50; Energy transition; High school.

How to cite: Martín, P.; Llavata, B.; Martínez, P.; Amer, E. and Girard, C. (2024) MiSchoolInTransition: learnings from the adaptation of the EuroNet 50/50 method in educational centres of the city of Valencia (Spain). In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 838-847.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The need for a clean and fair energy transition is now widely acknowledged at the world scientific level (IPCC, 2023) and at political levels in Europe to address the short-term energy crisis and mitigate the mid-term climate emergency (EC, 2019). However, our society is still facing multiple competing social, economic, and political trends that may challenge support from the population for ambitious climate policy, representing a cultural barrier to the energy transition. For a long time, efforts have been made to raise awareness about resource efficiency, especially among the youngest, by promoting the good energy-saving habits and behavioural changes (E. Ntona *et al.2015)*. This serves as a dual approach to directly reduce energy consumption, leading by example, but also to facilitate the understanding, development, and acceptance of ambitious public climate policies. Various programs, methods, and projects (Sánchez-Torija, et al. 2023) have been developed in educational centres, and the Euronet 50/50 method is now acknowledged and supported at the EU level to achieve effective energy savings and foster lasting environmental awareness in school communities (EURONET,2023). In this paper, we present an innovative adaptation of the Euronet 50/50 method in educational centres in the City of Valencia (Spain) known as the #MiSchoolInTransition (#MiCentroEnTransición, Oficina de la Energia, 2019) mentoring program. The #MiSchoolInTransition program, launched by the Municipal Energy Office of Valencia, is a service-learning program that combines learning with community services. It has been developed since 2019 by a team of environmental scientists and educational practitioners from the Energy Office of the city to support the development of Neighbourhood In Transition Projects toward the climate neutrality target of the city. The adaptation of the methodology for secondary schools, vocational training centres, and adult educational centres in Valencia city is described, as well as the first quantitative results of the projects that reached more than 6 000 people since the year 2020 and up to 12 558 kWh saved per year in a high school. This learning highlights the high potential of the method not only to produce short term quantitative impact, but as well long-lasting transformation dynamics in educational communities and beyond.

2. Method: #MySchoolInTransition, a service-learning approach adapting the Euronet 50/50 max

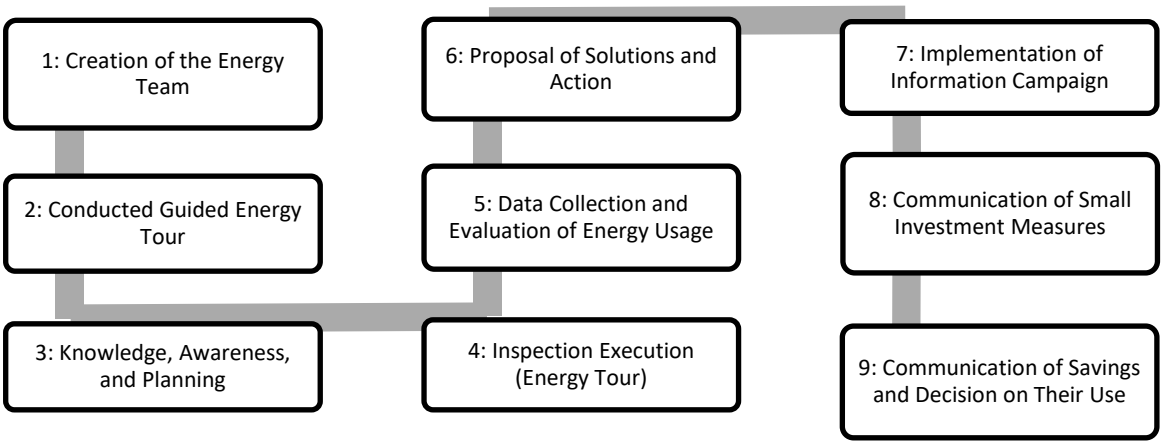
#MiSchoolInTransition follows a service-learning approach (Batlle, R. 2020). The approach is based on experiential learning while providing a service to the community. In this way, the goal is to make learning participatory and critical, shaping an active citizenship equipped with the necessary skills to navigate and transform the world. It allows, on the one hand, to provide a practical focus to curricular content, facilitating the assimilation of knowledge, and on the other hand, to guide learning towards solving community problems and applying knowledge

BY-NC-SA 2024, Editorial Universitat Politècnica de València

for the common good, empowering students as drivers of change in their immediate environment. It is an open methodology, sometimes included directly in pedagogical practice by teachers, but encompassing those educational processes that guide knowledge and values learning towards community action.

The current project focuses on reducing unnecessary consumption in educational centres in, saving energy, economic resources, and CO_2 emissions. It raises awareness about the direct relationship between energy production and consumption with the climate crisis while supporting educational centres in the energy transition. To achieve this, "energy teams" are formed in different educational centres, which are trained in energy matters and assisted in conducting an energy audit to improve the spaces and energy habits of the educational community.

Fig. 1 – Initial 9 phases of the Euronet 50/50 method



Source: Prepared by the authors on the basis of Euronet 50/50 (2023)

To carry out the energy audit in educational centres, the 50/50 Methodology of the Intelligent Energy Europe Programme of the European Union has been adapted. This methodology is designed for economic and energy savings in schools and public buildings, involving the people who use the facilities and raising awareness about environmentally friendly habits. This methodology consists of nine phases (Fig. 1). Upon completing the described phases, the educational centres achieve savings in their energy bills that impact local finances. Consequently, 50% of the savings are reinvested in the centre, while the remaining 50% constitutes a net saving for the administration.

#MySchoolInTransition adapts this methodology for implementation in secondary schools, vocational training centres, and adult educational centres and offer flexible but pragmatic approach based on three thematic Tours of the school. Thus, the phases of the #MySchoolInTransition project are as follows:

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Phase 1: Formation of Energy Team

To ensure project success and sustainability, the creation of an energy team within the centre is proposed. This team comprises one or two interested teachers and a group of students, with a usually recommended maximum of 10 participants. In high schools, working with entire classes has been considered, organizing the school into study zones assigned to workgroups. Active or informed participation of maintenance staff is crucial, and additional involvement of other members of the educational community is possible (Parents association, etc). Individuals, in these teams are trained and guided throughout the project. A first tour in the centre can be organized for everyone to share the same understanding of the local context if needed.

Phase 2: Training and Energy Audit

A theoretical and practical phase where students acquire the necessary knowledge to conduct an energy audit in their educational institution. It consists of the following sessions:

Session 1: Project Introduction. Climate change and energy.

To understand the relationship between global warming and energy production and consumption, it is first necessary to differentiate the concepts of greenhouse effect and climate change and explain the causes and consequences of the latter, using scientific literature and outreach materials (Royal Society, 2020; .

Session 2: Lighting Tour

The steps of lighting Tour are:

1. Identify the different types of luminaires (incandescent, halogen, low consumption, LED) and their properties (hours of duration, power, price, heat they give off).
2. Reveal the habits and opinion of the students about the use of the school's luminaires.
3. Identify the characteristics of the lighting system, number of lamps and their condition.
4. Promote critical review of the use of energy in lighting.
5. Think on how to improve consumption habits in terms of lighting.
6. Calculate CO_2 emissions due to lighting.

The tour is done with a Luxmeter to quantify and contrast light intensity in each space at a given time.

Session 3: Thermal Tour

Throughout the thermal survey of the centre, an initial overview of the heating system is conducted through a questionnaire. Each centre tailors the questionnaire to the specifics of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

its building. This introduces the topic of heating in a dynamic manner and allows identifying various types of heating systems, determining the one utilized by the centre, understanding its operating hours, identifying the responsible person, and noting the type of fuel used. To enhance theoretical understanding, a visit to the boiler room is arranged to observe firsthand its operation and the key elements in the heating system. The survey concludes with a thermal tour of the facility.

Fig. 2 – Group of Student visiting the boiler room of their centre during a thermal tour



Source: Authors

Session 4: Tour of Electrical and Electronic Appliances

The objective of this tour is to acquire proficiency in utilizing an energy meter and distinguishing between full-performance consumption, standby consumption, and phantom consumption of appliances. The distinction between the power required for an appliance to function and the energy consumed over a specific period will also be emphasized. During the tour, the power needed for the operation, standby consumption, and potential phantom consumption of some of the centre's EEA will be measured. An estimation of annual kWh consumption, its translation into the institution's electricity bill, and associated CO_2 emissions will be calculated for all cases.

Phase 3: Conclusions and Proposals

Throughout the tours, issues related to both habits and building infrastructure have been identified. At this stage, a compilation of the problems to be addressed becomes necessary. While the energy team has conducted the tours, this dynamic now involve the entire class from which the team originates, leveraging collective intelligence to propose solutions. Participants are divided into groups of 5 or 6, ensuring that each group includes at least one student who has conducted tours of the centre. This student can guide their peers in generating proposals and improvement solutions. A spacious classroom is needed to organize workgroups and facilitate the completion of forms and decision-making. To aid in summarizing conclusions and formulating initial proposals, standard cards are provided.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Phase 4: Project Communication

For the proposed decisions and measures to be implemented successfully, it is crucial for the entire educational community to be informed and engaged. Improvements may be attempted, but if no one is aware, the changes are often inconsequential. Communicating what has been done, why it has been done, and the resulting conclusions is as important as the actions taken thus far. The objective at this stage is to raise awareness among different audiences, promoting a shift in habits and attitudes. It is now the energy team's moment to educate their peers and the wider educational community about their findings, demonstrating what various users can do to conserve energy. Examples for informing the school community include: creating posters and wallpapering walls, presenting to the school board, Hosting an energy-saving week, conducting a good habits competition, developing a list of best practices and explaining it in each classroom, or creating an explanatory video.

Phase 5: Evaluation and follow-up

The exploration of different tour can be undertaken within a single academic year or distributed across multiple years as part of a long-term project. It is crucial that each time measures are implemented, whether from a partial or comprehensive study of the centre, their impact is assessed. The impact of these measures is evaluated both qualitatively and quantitatively. To estimate the level of emissions and the associated economic expenditure related to these energy savings, standard values have been used. For emissions estimation, the CO_2 emission factor from the 2022 electricity production mix has been applied, amounting to 0.27 kg of CO_2 per kWh. To calculate the economic savings, a value of €0.185 per kWh is considered. This value is derived by aligning the market price indexed to the average price of kWh in 2023 under the PVPC (regulated tariff), compensating for the charge differences between the two tariff types with the marketing margin applied to the indexed rate for each educational centre. This average price includes a 0.5% IE (Electricity Tax) and a 21% VAT.

3. Case study: Valencian Schools in transition

The Mediterranean city of Valencia, with approximately 800,000 inhabitants on the Eastern coast of Spain, has long been committed to climate change mitigation and promoting the transition to clean energy. This commitment is reflected in the corresponding Sustainable Climate and Energy Action Plans (SEAP, 2010; SECAP, 2019). Recently, Valencia was honoured as the EU Green Capital for the year 2024 and obtained one of the first Climate Mission City Labels from the European Commission. This recognition is a result of Valencia's Climate City Contract, aligning with the EU Climate City Mission's objective of achieving climate neutrality and reducing CO_2eq emissions by 80% by the year 2030.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

To achieve its ambitious climate targets and acknowledging that it needs to engage citizens in the energy transition journey to do so, the Valencia City Council, launched its first Energy Office in 2019. The Energy Office is a pioneering one-stop-shop initiative fostering citizen-led energy transition in Valencia's neighbourhoods. One of the pilar of the Office is its educational programme (#MySchoolInTransition) aiming at working with the educational centres surrounding the offices.

Fig. 3 – Representation of the educational centre (stars) involved in the #MiSchoolnTransition project around the Energy Office (heart)



Source: Authors

The program was initiated in late 2019 with the opening of the first Energy Office in Ayora. Up to now, #MySchoolInTransition has engaged 20 educational institutions, comprising 15 secondary schools, 3 adult educational centres, and 2 vocational training centres. To calculate savings, the 2023 consumption is compared with the average of the two preceding years. Data from 2020, influenced by Covid-related measures, has been excluded.

4. Results

Since 2020, 20 educational centres have participated in the #MySchoolInTransition initiative and a total of 372 workshops have been held in educational centres, where 11,175 participants from the educational communities of the centres have been trained.

Table 1 – Number of workshops and trained people per year

MiSchoolInTransition	2020	2021	2022	2023	Total
Workshops	75	126	96	75	372
Trained people	1202	2 376	2 084	1032	6694

Source: Authors

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The number of actions implemented in each institution depends on its size and specific needs, encompassing both energy and educational requirements. This adaptable approach ensures that the project accommodates realities.

To assess the project's impact, electricity consumption is monitored through meter readings (Table 2). Out of the participating institutions in 2023, which were also involved in 2022, data on the consumption of 4 are accessible through the i-DE electric distribution platform (High School Ramón Llull, High School Isabel de Villena, and High School Districte Marítim).

Table 2 – Annual Consumption (kWh) for the last 3 Years and Achieved Savings

High School name	Consumption kWh				Savings kWh
	2021	2022	Average	2023	2023
High School Ramon LLull	45.607	41.230	43.418	42.376	1.043
High School Isabel de Villena	79.435	59.038	69.237	56.679	12.558
High School Benlliure	125.749	117.785	121.767	140.437	-18.670
High School Districte Marítim	9.6191	91.746	93.969	85.727	8.241

Source: Authors

Table 3 – Savings achieved in kWh, kg of CO_2 and euros

High School name	kWh	kg of CO_2	€
High School Ramon LLull	1.043	282	193
Isabel de Villena High School	12.558	3.391	2.323
High School Benlliure	-18.670	-5.041	-3.454
High School Maritime Villages	8.241	2.225	1.525

Source: Authors

Savings have been observed in 3 out of the 4 institutions, totalling 21,842 kWh. However, the IES Benlliure experienced an increase in consumption. This institution had also participated in 2021, achieving savings of 7,964 kWh in 2022. In 2023, due to resource constraints at the institution, the project had fewer sessions than planned, and without proper support, the proposed measures were not finalized and communicated.

5. Conclusion

The #MySchoolInTransition initiative has developed a flexible and participatory methodology to overcome the limitations of traditional one-time awareness-raising interventions. Instead, it adapts the Euronet 50/50 method to fosters an ongoing dynamic to promote energy savings in neighbourhood schools with service-learning approach. Students

BY-NC-SA 2024, Editorial Universitat Politècnica de València

themselves conduct an energy diagnosis of the centre, identifying energy-related issues associated with space and habits, and collaboratively pinpointing solutions for shared areas.

Throughout the process, various segments of the educational community progressively engage through informative workshops, ensuring that the proposed measures have the maximum possible impact.

However, the experience in the implementation of the project shows some limitations in achieving long-term behaviour change and a sustained or even improved reduction in energy consumption over time. This is mainly since the people who are part of the educational community stay in the school for limited periods of time: the students advance courses until they pass the secondary school, most teachers do not have a fixed place in the centre and even the management of the centre changes periodically. In addition, legislative changes that lead to the emergence and disappearance of academic study subjects are frequent, forcing to look for new subjects in which to incorporate the content of the project. Although these changes may hinder improvements in the educational centre, it allows #MySchoolInTransition to be known in the centres receiving already trained people and the resulting difficulties are being overcome due to the flexibility of the approach.

Given the success of the initial years, this adaptation of the Euronet 50/50 method is being extended to new educational centres and key entities in the neighbourhood, such as Popular Universities, Vocational Centres, or even University living labs, encouraging their participation in the Neighbourhood in Transition initiative.

Acknowledgements

Thanks to all the students, teachers and members of the school communities that have contributed to the project. The Project is funded by the Valencia Climate an Energy Foundation of the City Council of València.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

EC, European Comision (2019). COMUNICACIÓN DE LA COMISIÓN AL PARLAMENTO EUROPEO, AL CONSEJO EUROPEO, AL CONSEJO, AL COMITÉ ECONÓMICO Y SOCIAL EUROPEO Y AL COMITÉ DE LAS REGIONES El Pacto Verde Europeo. https://eurlex.europa.eu/legal-content/ES/TXT/?uri=celex%3A52019DC0640.

EURONET 50/50, (2023). http://www.euronet50-50max.eu/es/

2024, Editorial Universitat Politècnica de València BY-NC-SA

Jorge Gallego Sánchez-Torija, Clara García López & María Antonia, Fernández Nieto, (2023). Energy, water and economic savings by changing habits of users in twelve schools in Spain, Building Research & Information, https://doi.org/10.1080/09613218.2023.2277469

IPCC, (2023). Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 1-34, https://doi.org/*10.59327/IPCC/AR6-9789291691647.001.*

Oficina de la Energia, (2019). EcoAuditoria: Mi Centro En Transicion https://climaienergia.com/wp-content/uploads/2023/07/Ecoauditoria_OE_cast.1.pdf

NOAA, 2009, Climate Literacy Climate Literacy The Essential Principles of Climate Science, https://downloads.globalchange.gov/Literacy/climate_literacy_highres_english.pdf

Eirini Ntona, Garyfallos Arabatzis and Grigorios L. Kyriakopoulos, *2015* Energy saving: views and attitudes of students in secondary education Renew. Sustain. Energy Rev vol. 46, issue C, 1-15 https://doi.org/10.1016/j.rser.2015.02.033

RoyalSociety,2020 A SHORT GUIDE TO climate science https://royalsociety.org/-/media/policy/projects/climate-evidence-causes/climate-change-q-and-a.pdf

BY-NC-SA 2024, Editorial Universitat Politècnica de València

The ECF4CLIM Ecological Footprint Calculator as an awareness tool to promote more sustainable behaviors in educational centers

Ana Rosa Gamarra[a], Carmen Lago[a] , Yolanda Lechón[a] and Isabel Preto[b]

[a]CIEMAT, Spain
[a]ENLITIA, Portugal

Abstract

The European project ECF4CLIM main goal is the development of an European Competence Framework for sustainability (ECF) in educational centers (primary, secondary and university) through a novel participatory, multidisciplinary and transdisciplinary process. Once developed, the ECF will be tested and validated to generate a transformational change that will enable the educational community to be empowered by facilitating action against climate change and towards sustainable development. Practical learning will be promoted through the development of a set of innovative tools (digital platform for crowdsourcing, environmental footprint and energy efficiency calculators, IoT solutions for real-time monitoring of selected parameters and a digital learning space, available on the web for educational centres and the general public.This communication focuses on the development of an environmental footprint calculator, based on LCA methodology and adapted to educational centres. This tool makes it possible to quantify the environmental impact of the different activities carried out in the educational centres, divided into three subsystems: School Management Activities, Teaching and Learning Tasks and Transport and Mobility Behaviour. On the basis of the results, it is possible to propose improvements to the activities of the educational centres in order to reduce the environmental impact associated with the operation of the primary, secondary and university schools, quantifying the savings in emissions and the reduction in the environmental impact.

Keywords: environmental footprint calculator; Life Cycle Assessement (LCA); environmental and energy performance; environmental impacts; educational centers.

How to cite: Gamarra, A.R.; Lago, C.; Lechón, Y. and Preto, I. (2024) The ECF4CLIM Ecological Footprint Calculator as an awareness tool to promote more sustainable behaviors in educational centers. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 848-856. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The environmental footprint is a methodology that measures the impact of people or organizations on the environment, whether the result is positive or negative. In the case of organizations, it is defined as a multi-criteria measure of the environmental performance of their activity when providing goods or services, taking into account the entire life cycle.

The aim of using these methods is to support the transition to more sustainable performance in schools by monitoring and benchmarking environmental and energy performance, and identifying sustainable and cost-effective solutions based on procurement and behavioural measures. The use of an environmental footprint calculator will enable schools and students to self-assess their performance by identifying hotspots and opportunities for environmental improvement. It will also serve to raise the awareness of the educational community of their impact on the environment.

There are many online footprint calculators available (Mulrow, et al. 2018). In general, online footprint calculators vary widely in detail and scope, but they usually focus only on global warming emissions and are aimed at individual users. There are some initiatives of calculators aimed at educational communities (Wagner et al, 2021; Valls-Val and Bovea, 2021 and 2022), but again they limit the analysis to global warming emissions. Furthermore, regional and product-specific customisation is rare among calculators (Mulrow, et al. 2018).

The Environmental Footprint Calculator developed in ECF4CLIM is based on the Life Cycle Assessment (LCA) methodology and has been aadapted to the activities performed in educational institution . In addition to climate change impacts, the ECF4CLIM Environmental Footprint Calculator includes a complete set of environmental impacts, including global impacts, human health impacts, ecosystem impacts and resource depletion impacts.Three versions of the calculator have been developed, adapted to three different levels: a simpler version for primary school students, which only considers climate change impacts and the water footprint; a second version for secondary school and university students; and a third, more complex version for educational centre managers.

In all cases, we have tried to make them easy to understand for non-experts through three main points: 1) open online tools, available not only for the 13 demonstration centers (the schools, secondary schools and universities that are participating partners in the ECF4CLIM project) and easily accessible to everyone; 2) simple design to enter data and display results; and 3) better adapted to user profiles (including age, complexity and activities). A web version is available at ecf4clim-app.smartwatt.net/app/footprint-calculator

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Methodology and structure

The calculator is based on the multi-criteria and holistic Life Cycle Assessment (LCA) methodology following the guidelines of ISO 14040 and ISO 14044 standards. LCA is a methodology that allows the evaluation of the environmental impacts associated to all the stages of a product's life cycle includimg raw material extraction, processing, manufacturing, transport and distribution, use, reuse and recycling and final disposal.

The development of an LCA encompasses four phases: i) Definition of objective and scope; ii) Inventory Analysis; iii) Impact Assessment and iv) Interpretation of results.

2.1 Environmental Footprint Calculator design based on LCA

The first step was to identify the school system according to the goal, scope and main components of the School and Students systems (Primary Students and Secondary and University Students). Then, a template was designed to collect input data from schools in order to build the inventory (inputs and outputs of material and energy related to each component of the system).

Taking into account the inventory data (activities, processes, flows, etc.), a database (BBDD) of environmental impact characterization factors was developed linked to them. This allows the quantification of the impact including several environmental impact categories. Finally, the results are presented graphically to allowinterpretation. The tool contains two types of information:

- Calculations and relationships between inputs and outputs, and between processes of different activities, linking inflows and outflows, in appropriate units to be connected with Impact factors
- Factors database calculated per unit processes to be linked with impact factors

2.2 Goal and scope definition

The goal of this Life Cycle Assessment (LCA) is to quantify the environmental impacts associated with the consumption of energy, materials, and water in educational centers (referred to as demonstration sites in the ECF4CLIM project) or schools located in Europe. This specifically includes regions in Spain, Finland, Romania, and Portugal. Additionally, there is an option to select an unspecified country within the European region (EU-27), with the UK also available...

Functional unit. The function addressed by these LCA-based tools is to support education through two main aspects: (a) For the Managers tool, it involves facilitating student activities for an annual season And (b) For the Primary, Secondary, and University Students tools, it includes providing supply and demand resources for students engaged in basic activities

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

associated with learning at home.The inventory of the total consumption of energy, materials and water will refer to this period and will be calculated per school (only Managers tool), and/or per student.

Scope and system boundaries. The work focuses on quantifying the environmental impact of educational activities per student. Three tools for three scopes have been developed according to the Users profiles:

- **EFC tool for Primary School Students**: includes the calculation of the Carbon and Water footprint associated to the materials and devices required for learning, as well as some other activities at home such the wastes produced, new clothes throughout the year, the shared use of some materials and equipment, and the mobility behaviour to go to school and transport for family trips.
- **EFC tool for Secondary and University Students**: includes the calculation of the Environmental footprint (Carbon and Water footprint, and also ten additional environmental impact categories) related to:

a. Household activities and consumption (electricity, heating, cooling, water, lighting, waste, kitchen);

b. The student's own consumption (consumption of the materials and equipment required for learning, as well as some other activities such waste produced, new clothsthroughout the year and shared consumption at home)

c. Transport, including the mobility behaviour to go to school and transport for family trips.

- **EFC tool for Managers of Educational Centres**: includes the calculation of the Environmental footprint (Carbon and Water footprint, as well as ten additional environmental impact categories) related to:

a. The activities and consumption of the school or educational centre building (electricity, heating, cooling, water, lighting, wastes, etc.);

b. The consumption and materials for teaching and learning provided by the school (paper, printed documents, sports' material, library, audio-visual resources and equipment, among others) and the wastes produced.

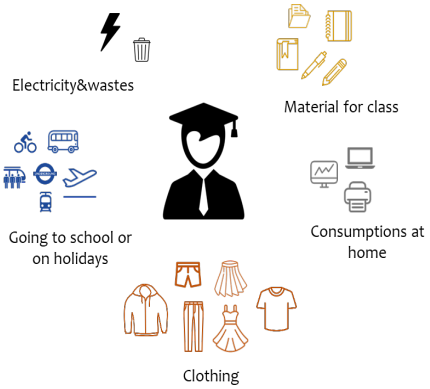
c. Transport for excursions provided by the school.

Note that the tool for Manager's tool requires data from the students to collect some of the information (consumption of learning materials by students). For this purpose, a questionnaire is provided to support the data collection and analysis. In addition, the participation of the school staff in data collection on waste, gardening or cleaning maintenance activities will be essential involving the whole community.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

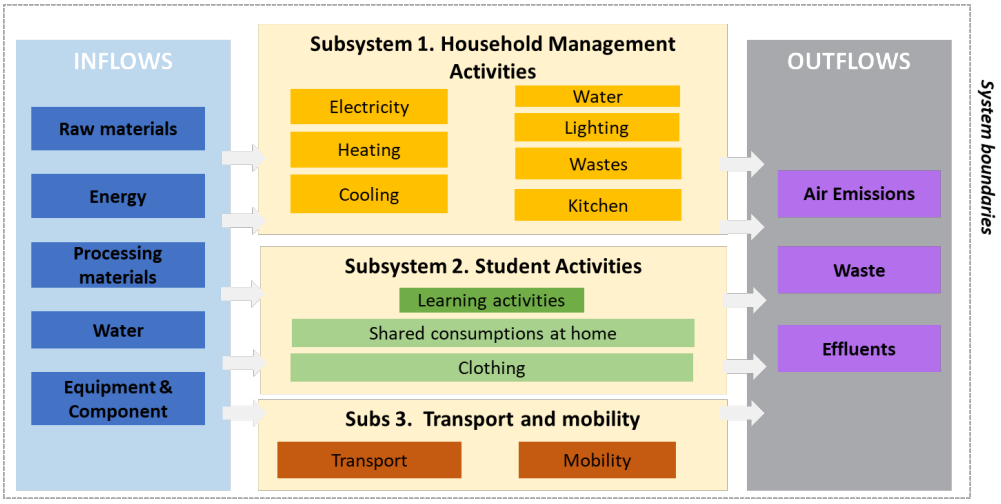
The figures below show the system boundaries considered and the activities included in each EFC tool. As can be seen, the system in more complex for Managers as it involves the whole school system. The tool for Secondary and University student is simpler that the tool for managers and the data is easier to estimate and can be obtained from bills and observation. In addition, the Primary students system is the simplest as it only requires the children to self-assess and reflect on their learning consumption, waste, clothes and equipment use, as well as their experience (how they go to school every day or the transport used on holidays, e.g).

Fig. 1– Primary Student system



Source: Gamarra et al. (2023)

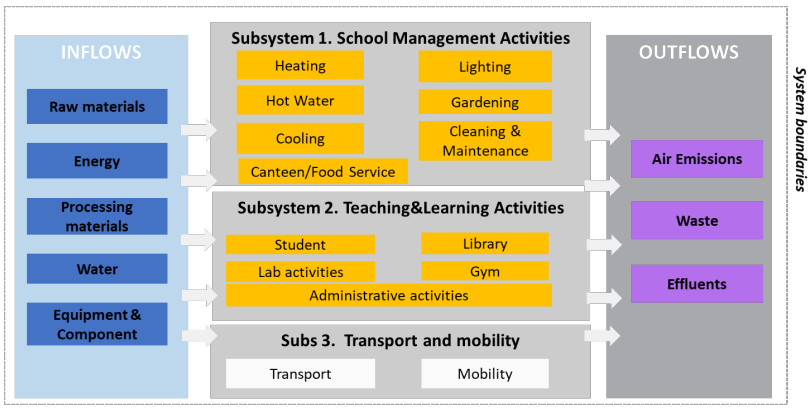
Fig. 2 – Secondary and University Student system



Source: Gamarra et al. (2023)

 BY-NC-SA

Fig. 3 – School Managers system



Source: Gamarra et al. (2023)

Activities and processes whose contribution to mass and energy flows and emissions are relevant to the environment were identified and investigated. Ecoinvent database has been used for the most common processes such as transport, fuels and basic materials and chemicals. The LCA software used to modelled processes has been SIMAPRO™.

3. Results & findings

The tool for students presents the results of the environmental footprint per person while the tool for Managers presents the results per impact category in terms of totals of the school, per student and per square meter. The results are disaggregated considering the contribution of the different elements of the system to compare the contribution to the total system impact, and the activities in each subsystem impact to be able to self-assess the hotspot and focus on the potential improvements. Some screenshots of the calculators are shown below:

Fig. 5 – Example of results visualization for EFC tool for Secondary and University Students

School User Footprint calculator

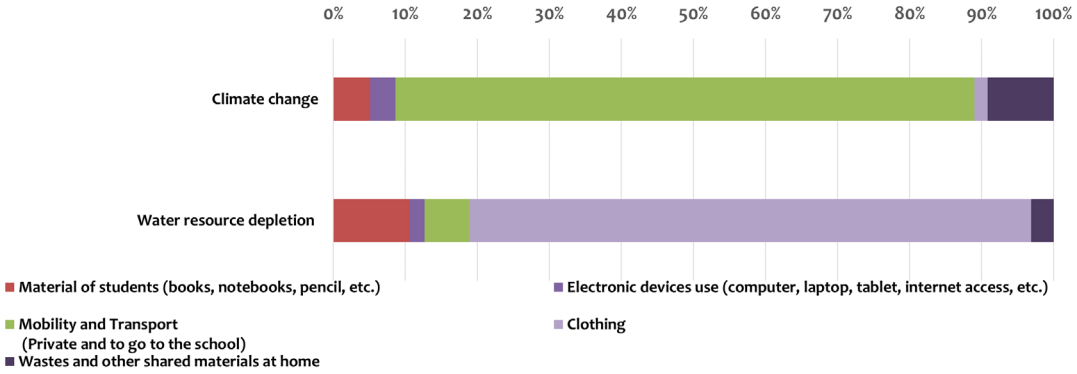
PRIMARY student

TOTAL RESULTS	Climate change kg CO2 eq	Water resource depletion litres water eq
Material of students (books, notebooks, pencil, etc.)	31,77	682,3
Electronic devices use (computer, laptop, tablet, internet access, etc.)	21,9	130,9
Mobility and Transport (Private and to go to the school)	498,0	399,3
Clothing	11,4	4999,9
Wastes and other shared materials at home	56,7	199,5
Total	**619,8**	**6411,9**

Source: Gamarra et al. (2023)

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig.6 – Example of the results visualization for EFC tool for Primary students (graph)



Source: Gamarra et al. (2023)

Fig. 7 –Example of the results display for EFC tool for Primary students

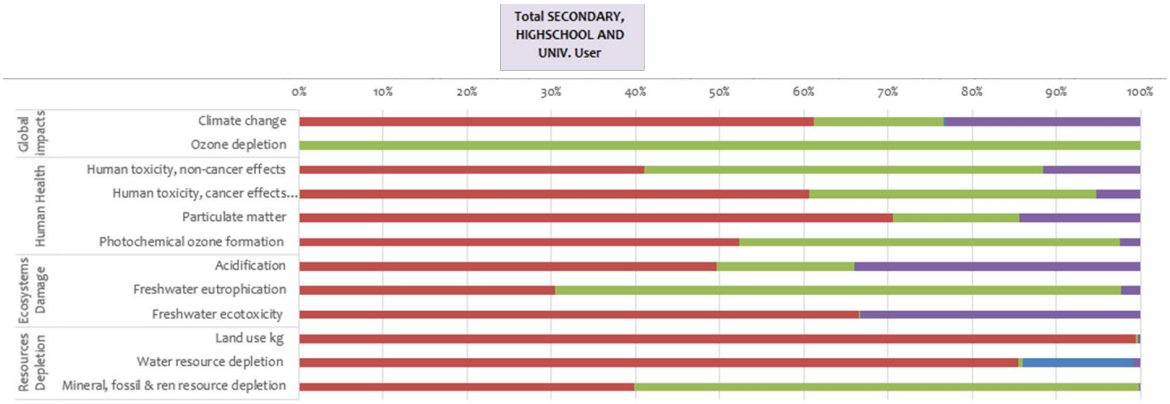
School User Footprint calculator USER OF SECONDARY, HIGHSCHOOL AND UNIV. STUDENT	Global impacts		Human Health			
	Climate change kg CO_2 eq	Ozone depletion kg CFC-11 eq	Human toxicity, non-cancer effects CTUh	Human toxicity, cancer effects CTUh	Particulate matter kg PM2.5 eq	Photochemical ozone formation kg NMVOC eq
Household footprint	752,1	4,71E-03	6,21E-05	1,42E-05	0,296	57,9
Learning Activities	108,5	1,26E-05	6,70E-05	6,89E-06	0,060	0,4
Clothing	2,5					
Mobility and Transport	1020,8	1,38E-04	4,95E-05	3,54E-06	0,235	3,8
Total	1883,9	4,86E-03	1,79E-04	2,47E-05	0,592	62,1

School User Footprint calculator USER OF SECONDARY, HIGHSCHOOL AND UNIV. STUDENT	Ecosystems Damage			Resources Depletion		
	Acidification mol H+ eq	Freshwater eutrophication kg P eq	Freshwater ecotoxicity CTUe	Land use kg C deficit	Water resource depletion m^3 water eq	Mineral, fossil & ren resource depletion kg Sb eq
Household footprint	1,9	0,438	285,8	231,2	24,5	0,212
Learning Activities	0,7	0,050	1733,6	199,9	0,7	0,107
Clothing					3,8	
Mobility and Transport	4,1	0,036	645,8	-4,9E-02	0,9	0,001
Total	6,7	0,524	2665,2	431,0	30,0	0,319

Source: Gamarra et al. (2023)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 8 – Example of results visualization for EFC tool for Secondary and University Students (Graph)



Source: Gamarra et al. (2023)

4. Conclusions

Sustainability education plays an important role in achieving the environmental protection needed for future generations. Environmental impact calculators are key tools to support sustainability education. Used in schools or universities, these tools enable students and managers to assess the impact of their daily activities, learn how to reduce it, and raise awareness to take actions that support more sustainable behaviour changes. Making the invisible visible by quantifying, evaluating and comparing the environmental impact of our daily activities. In general, calculators available to educational communities focus only on climate change impacts and do not take into account other important environmental impacts. The environmental footprint calculator developed in this project goes beyond the carbon footprint and takes these other impacts into account. Calculators need to be adapted to the different levels at which they are aimed (primary education, secondary education and managers). This was addressed in our project by developing three different versions of the calculator. In addition, the level of complexity of the calculators requires some effort prior to their use and, as in the case of the calculator for managers, they may require the use of actual data on the school's operations obtained from previous environmental audits. The ECF tools developed in ECF4CLIM are in the process of being tested by students and managers at our demonstration sites during the spring of 2024.

Acknowledgements

The authors wish to express their gratitude for the financial support from H2020-LC-GD-2020-3, Project 101036505, ECF4CLIM, European Competence Framework for a Low Carbon Economy and Sustainability through Education.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Collins, A.; Galli, A.;, Patrizi, N.; Pulselli, F.M. (2018). "Learning and teaching sustainability: The contribution of Ecological Footprint calculators". Journal of Cleaner Production 174, 1000-1010.

Edstrand, E. "Making the Invisible Visible: How Students Make Use of Carbon Footprint Calculator in Environmental Education".(2016). Learning, Media and, 41(2), 416-436 2016

Gamarra, A.R., Lechón Y., Lago C. Environmental footprint calculator (EFC) tools. ECF4CLIm Project Deliverable (November 2023). https://www.ecf4clim.net/_files/ugd/1088b3_eaf1006 9587 64cae84a9423c3b53b76a.pdf

ISO 14040: Environmental Management – Life Cycle Assessment. Principles and Framework. ISO 14041: Environmental Management – Life Cycle Assessment. Goal and Scope Definition and Inventory Analysis.

ISO 14042: Environmental Management – Life Cycle Assessment. – Life Cycle Impact Assessment.

ISO 14043: Environmental Management – Life Cycle Assessment. Life Cycle Interpretation.

ISO 14044.2006: Environmental Management – Life Cycle Assessment. Requirements and guidelines.

Oele, M.; Dolfing, R.; Grace, V. "SimaPro 9.5. Full update instructions. PRé Sustainability Version: 1.0" (April 2023).
https://simapro.com/wp-content/uploads/2023/07/FullUpdateInstructionsToSimaPro950.pdf

The Ecoinvent database version 3 (part I): overview and methodology. The International Journal of Life Cycle Assessment, [online] 21(9), pp. 1218–1230.

Valls-Val,K.; Bovea, M.D. (2022). "Carbon footprint assessment tool for universities: CO2UNV". Sustainable Production and Consumption, 29, 791-804.

Valls-Val, K.; Bovea, M. D. (2021). "Carbon footprint in Higher Education Institutions: a literature review and prospects for future research". Clean Technologies and Environmental Policy, 23:2523–2542.Wagner, O.; Tholen, L.; Nawothnig, L.; Albert-Seifried, S.(2021). "Making School-Based GHG-Emissions Tangible by Student-Led Carbon Footprint Assessment Program". Energies, 14, 8558.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The potential use of infrared cameras to provide a meaningful understanding of thermal science at different levels of education

Mar Cañada-Soriano[a], Guillermo Vilariño-Feltrer[a] and Rafael Royo-Pastor[a]

[a]Department of Applied Thermodynamics, Universitat Politècnica de València, Spain

Abstract

The integration of infrared thermography has proven to be a powerful tool in educational programmes but also in local councils to highlight the importance of adopting energy efficiency measures. The use of infrared cameras in thermal science education facilitates an immersive learning experience for students, enabling them to grasp complex and abstract concepts more effectively. This work presents different activities developed with thermal cameras involving students at different educational levels. The experiences were aimed at describing the conduction heat transfer through the effect of insulation in a wall and the spectral behaviour of surfaces in terms of radiation. Incorporating handheld thermal cameras into the learning process actively engages students and promotes a deeper and more meaningful learning experience. Therefore, infrared cameras show a potential to be used in educational frameworks to enhance understanding of thermal science concepts and contribute to sustainable practices.

Keywords: thermal science; infrared cameras; conduction; radiation; education.

How to cite: Cañada-Soriano, M.; Vilariño-Feltrer, G and Royo-Pastor, R. (2024) The potential use of infrared cameras to provide a meaningful understanding of thermal science at different levels of education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 857-865.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In face of escalating climate change concerns, the building sector stands at the forefront of global efforts to both mitigate environmental impact and foster sustainability. The building sector accounts for 40% of the primary energy demand and over one third of the EU's energy-related greenhouse gas emissions come from buildings (European Comission, n.d.). The European commitment to the global climate action is growing globally, with the most ambitious goal of achieving climate neutrality by 2050. Among energy policies and regulations addressing the low-carbon agenda, the Energy Performance of Building Directive (EPBD) sets standards for the energy performance of new buildings and promotes the energy-efficient renovation of the existing building stock (European Comission, n.d.). It should be noted that 85% of the buildings in the EU were constructed before the year 2000, and of these it is estimated that 75% have poor energy performance. Among the strategies and measures to be implemented by the EU are training programmes aimed at preparing professionals for the paradigm shift required to achieve the ambitious goal of zero-emission buildings. Additionally, initiatives promoting sustainable practices and behaviours that contribute to the overall energy efficiency and emissions reduction of buildings should be extended to end-users.

However, theoretical concepts related to thermal energy are usually difficult to understand and learn in a meaningful way because they are abstract and intangible. The utilisation of different learning methodologies, such as the incorporation of simulation environments or computational tools, facilitates high interactivity among learners and facilitates the development of a more comprehensive understanding (Xie, 2012; Xie et al., 2023). Visual support techniques such as infrared thermography (IRT) constitutes a powerful tool in the teaching-learning processes since it has the potential to translate abstract concepts into images, making them more tangible and understandable. Thermal cameras capture infrared radiation from the bodies' surfaces and converts it into visible images (Vollmer M, 2017). In some cases, community groups and local councils rely on this tool to highlight anomalies to users and for encouraging them to adopt energy efficiency measures (València Clima i Energia). Because it is intuitive and involves the learner, the use of thermal imaging in education has also proven to be a useful tool at various levels of education,(Cañada-Soriano et al., 2020; Haglund et al., 2016; Möllmann & Vollmer, 2007).

In this work, different energy related activities that could be both demonstrated and explained with thermal cameras are presented. In addition, the level of student satisfaction has been collected through satisfaction surveys.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

2. Methodology

Practical examples were presented based on `prediction – observation – explanation'. The starting point was always the presentation of thermal images through situations that were familiar to the students (e.g. the use of infrared images or cameras in series, films, news, or sports) in order to engage them. Then, the energy related concepts under analysis were demonstrated through the thermal images. To this purpose, different handheld infrared cameras of different specifications (C5, S640, T1020 models by FLIR Systems) were used, all of them working within the longwave range from 8 to 14 μm.

The activities presented were carried out at two different educational levels. On the one hand, in the years 2022 and 2023, workshops known as Ciencialab were held at the UPV for groups of 20-25 secondary school students, with the aim of awakening a scientific vocation. On the other hand, these activities were also carried out during the first part of the subject: "Heat Transfer" taught in the second course of the Energy Engineering degree at ETSII (UPV).

Surveys were carried out to measure student satisfaction levels. In the case of Ciencialab, surveys were conducted at the end of the workshop with a sample of students who were asked to rate how they found the workshop on a scale of 1 (very bad) to 5 (very good). In 2022, 54 students responded to the survey, while in 2023, 14 students responded to the survey due to fewer workshops being held. In the case of the second year students of Heat Transmission, an online survey with 3 questions was carried out on the use of thermal cameras combined with traditional teaching. The survey was available to all 96 students enrolled on the course, of whom 31 responded.

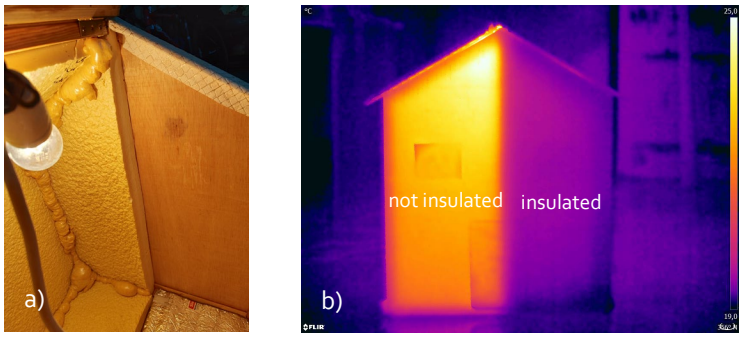
3. Results

3.1 Activities

To demonstrate heat transfer by conduction, a model in the shape of a house made out of wooden planks was used. Half of the walls of the house had 5 cm of insulation on the inside, while the other half had no insulation at all, which could not be seen from the outside with the naked eye. Moreover, inside the model house a constant heat source was switched on for a while before the activity, which could not either be distinguished from outside (Fig. 1a). When the model house was then observed from outside with the thermal camera, the lack of insulation could be quickly identified (Fig. 1b).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 – A model in the shape of a house. a) Picture showing the half-insulated wall from inside, b) The thermal image from outside



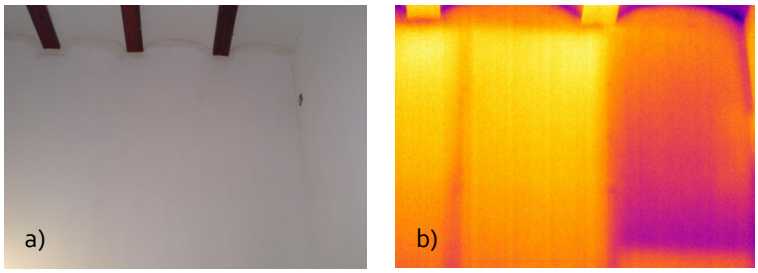
Source: Own elaboration

The heat transfer rate under steady-state through a composite wall made of different layers can be defined by the equation below (Incropera, 2006):

$$q_{cond}\,(W) = UA \cdot \Delta T$$

Where ΔT (ºC) is the overall temperature difference, q_{cond} (W) is the heat transfer rate through the wall, and U (W/m²K) is the overall heat transfer coefficient. Assuming the heat flux is constant and the temperatures inside and outside as well, the largest temperature drop would take place in the most insulated layer (lower U value). Figure 2 shows this effect in a real scenario of a home energy renovation. In this case, lack of insulation in an area of a wall was detected by means of infrared thermography.

Fig. 2 – Real case of energy refurbishment once is finished. a) Picture the wall, b) Thermal image of the wall



Source: Own elaboration

The heat transfer by radiation is complex and abstract but essential. The activity concerned is designed to explain how different surfaces exhibit distinct behaviour depending on the wavelengths of the electromagnetic spectrum. For this purpose, a ceramic cup on which different coloured ribbons have been attached is used, as shown in Fig. 3a. The thermal camera shows that the cup filled with hot water has a uniform surface temperature and the colour bands attached to the outer surface are indistinguishable (Fig. 3b).

2024, Editorial Universitat Politècnica de València BY-NC-SA

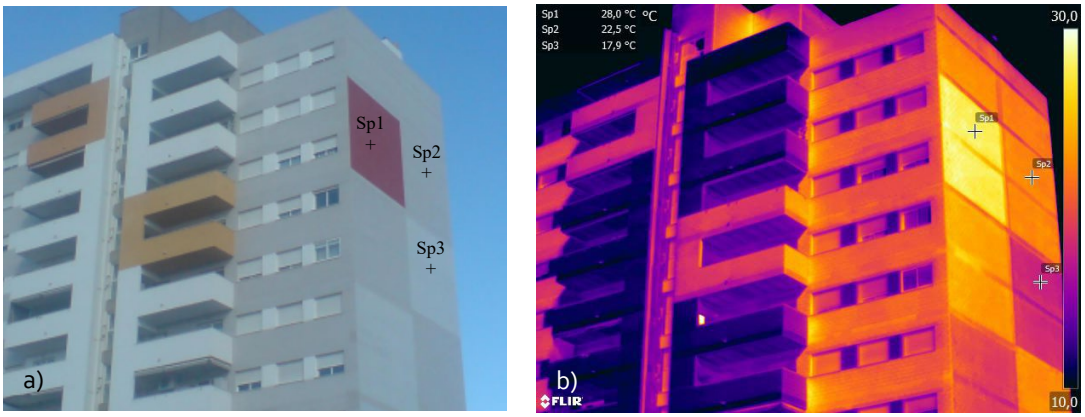
Fig. 3 – Ceramic cup with color tapes attached to it in a) visible and b) thermal.



Source: Own elaboration

But why is a dark car warmer than a white one if colours are not affected by radiation? This phenomenon is due to the properties of a surface to absorb and emit radiation which depend, in turn, on the wavelength of the radiation. The spectral distribution of incident solar radiation differs significantly from the spectral distribution of emitted radiation by surfaces since the former is concentrated in the short-wavelength region whereas the latter in the infrared region. Hence, the surfaces present two different properties: one for solar incident radiation (solar absorptivity: α_s) and another for infrared radiation at room temperature (emissivity: ε) (Incropera, 2006). The solar absorption of a white painted surface ($\alpha_s \approx 0.14$) is much lower than that of a dark surface ($\alpha_s \approx 0.95$), and since a dark colour has the ability to absorb more sunlight than clear colours, it gets hotter in the sunlight.

Fig. 4 – A building facade in a) visible and b) thermal



Source: Own elaboration

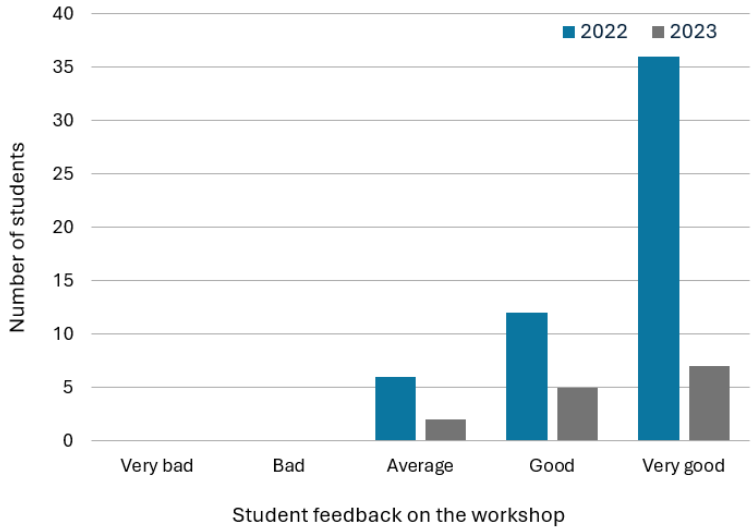
As it is shown in Fig. 4, the red part of the façade is at a higher temperature than the clear parts ($T_{white} < T_{grey} < T_{red}$) because each has a different absorption to visible light ($\alpha_{s,\,white} < \alpha_{s,\,grey} < \alpha_{s,\,red}$). However, for infrared radiation (long wave, at which thermal cameras operate), colours present the same behaviour and, therefore they emit the same radiation regardless of their colour ($\varepsilon_{blue} = \varepsilon_{black} = \varepsilon_{red} \approx 0.95$) (Fig. 3b).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.2 Student responses

As described in section 2, students from Ciencialab (secondary education) and Heat Transfer (second degree at university) responded to a satisfaction survey. Regarding the Ciencialab workshops (Fig.5), 66.67% and 50% of the students in 2022 and 2023 respectively found the workshop very good. 22.2% and 35.7% of the students thought that the workshop was good. It should also be noted that none of the students interviewed considered the workshop to be bad or very bad.

Fig. 5 – Distribution of the student satisfaction in Ciencialab workshops



Source: Own elaboration

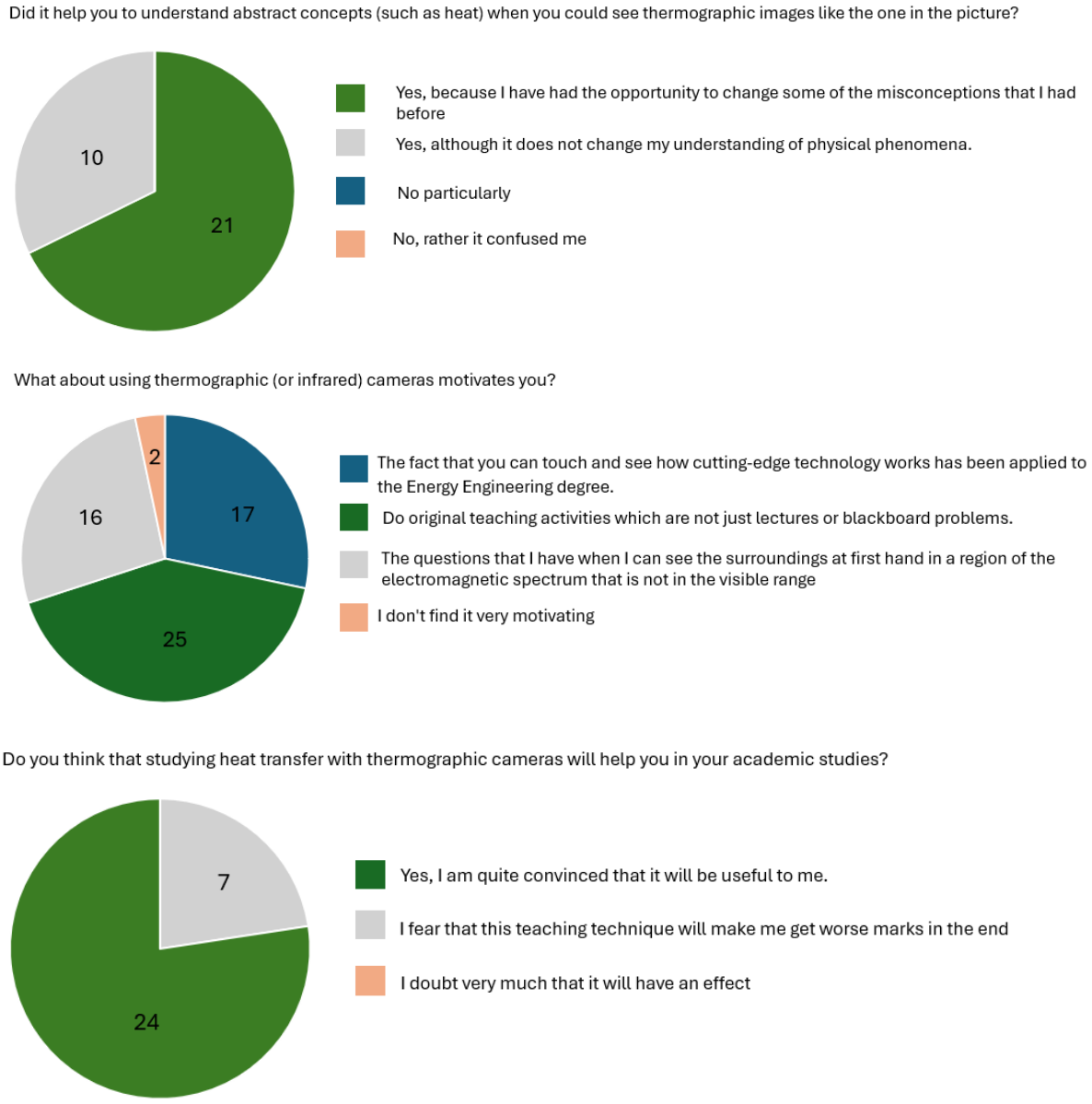
On the other hand, a three-question online survey (Fig. 6) was sent to the students of Heat Transfer in Energy Engineering. The survey was completed by 31 of the original 96 students enrolled in the course. When asked "whether looking at thermographic images helps them to understand abstract concepts", 21 of the 31 students said yes, because it allows them to modify erroneous ideas they previously had, while the other 10 also said yes, although they believed it would not change their understanding of physical phenomena. No students responded that thermography did not help them understand abstract concepts when asked the same question. In response to the second question about "what motivated them to include thermal imaging in the course", they were able to select more than one option. In this case, carrying out original teaching activities, which are not simply a masterclass or solving a problem on the blackboard, accounts for 41.67%, followed by touching and seeing how cutting-edge technology used in the Energy Engineering course works, with 28.33%, and issues arising from being able to see the environment at first hand in a region of the electromagnetic spectrum other than the visible, with 26.67%. Only two students didn't find the use of infrared cameras very motivating. Finally, 24 out of the 31 students are quite convinced that studying heat transfer with thermographic cameras will be useful for their

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

academic results in the subject, while 7 students are very doubtful that it will have an effect on their results. When asked the same question, none of the students feared that this teaching technique would result in a lower mark.

Overall, the results revealed that students generally felt that the use of thermal imaging cameras had a positive impact on their learning experience.

Fig. 6 – The survey of the students of heat transfer and the results obtained from it.



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

4. Conclusion

The integration of infrared thermography in science education has proven to be a powerful tool across various educational levels since it allows students to bridge the gap between theoretical principles and real-world applications. The use of handheld thermal cameras in the classroom emphasizes the practical application of theoretical knowledge and fosters a deep and meaningful understanding of abstract energy concepts. Based on student feedback, the use of thermal imaging cameras helps them understand abstract concepts and it can also increase their motivation. This learning tool actively engages students through hands-on experiences that can often be translated into real-world situations. Incorporating infrared thermography into educational frameworks, not only promotes the understanding of thermal science concepts, but it also contributes to sustainable thinking practices that could be implemented in the built environment. The current affordability and accessibility of handheld thermal cameras, some of which are compatible with a smartphones and tablets, make them versatile and convenient tools to support the learning process.

Therefore, the use of thermography at different levels of the educational context presents educational benefits, but can also promote sustainable practices and highlight the importance of adopting energy efficiency measures. In this sense, incorporating this visual technique in the learning experience would also be a good way to raise students' awaraness of sustainable development and make a positive contribution to achieving the United Nations Sustainable Development Goals (SDGs), particularly Goals 4 (quality education), 11 (sustainable cities and communities), 12 (responsible consumption and production) and 13 (climate action).

Acknowledgements

The authors would like to thank the funding of this work to the "Innovación y mejora educativa aplicada a los Objetivos de Desarrollo Sostenible en la ETSII" project (PIME/21-22/281), financed by Vice-Rectorate for Organization of Studies, Quality, Accreditation and Languages of the Universitat Politècnica de València.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

References

Cañada-Soriano, M., Rodríguez-Hernández, J.-C., Vilariño-Feltrer, G., Vallés-Lluch, A., & Moratal, D. (2020). Strategies to teach energy-related concepts to elementary school students through visual activities and laboratory experiments. *INTED 2020 Conference*, 5197–5201. https://doi.org/10.21125/inted.2020.1406

European Comission. (n.d.). DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings. *Journal of the European Union*.

Haglund, J., Jeppsson, F., & Schönborn, K. J. (2016). Taking on the Heat—a Narrative Account of How Infrared Cameras Invite Instant Inquiry. *Research in Science Education*, *46*(5), 685–713. https://doi.org/10.1007/s11165-015-9476-8.

Incropera, F. P. (2006). *Fundamentals of Heat and Mass Transfer*. John Wiley & Sons, Inc.

Möllmann, K.-P., & Vollmer, M. (2007). Infrared thermal imaging as a tool in university physics education. *European Journal of Physics*, *28*(3), S37. https://doi.org/10.1088/0143-0807/28/3/S04.

Oficina de l'energia. València Clima i Energia. Available from: https://climaienergia.com/oficina/estalvi-rehabilitacio/

Vollmer M, M. MK. (2017). *Infrared thermal imaging : fundamentals, research and applications*. Wiley-VCH.

Xie, C. (2012). Interactive Heat Transfer Simulations for Everyone. *The Physics Teacher*, *50*(4), 237–240. https://doi.org/10.1119/1.3694080.

Xie, C., Ding, X., & Jiang, R. (2023). Using Computer Graphics to Make Science Visible in Engineering Education. *IEEE Computer Graphics and Applications*, *43*(5), 99–106. https://doi.org/10.1109/MCG.2023.3298386.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Living labs and collaborative initiatives on European university campuses for sustainability learning: SusTIMEability-lab project

Carla Montagud Montalvá, Javier Sanchis Saez, Javier Soriano Olivares, Ángel Sapena Bañó, Arantxa Querol Monforte and Elisa Peñalvo López

School of Industrial Engineering, Universitat Politecnica de Valencia, Spain

Abstract

Universities play a crucial role in addressing the climate emergency and developing effective decarbonisation strategies. This includes training graduates who will be responsible for both mitigating and adapting to climate change. It is important for universities to adopt best practices in this area. In this context, universities can use living lab and collaborative initiatives for sustainability learning not only for educational purposes but also as a sandbox to develop and test innovative solutions on their campuses before transferring them to the cities where they are located. Four European universities, namely Universtitat Politècnica de València, KTH Royal Institute of Technology, École Centrale Méditerranée, and Delft University of Technology, collaborated on a joint project entitled SusTIMEability-lab. These universities are situated in cities, including Valencia, Marseille, Stockholm, and Amsterdam, which have been selected by the European Commission to become carbon neutral by 2030. Multidisciplinary teams were created, consisting of students from various engineering, design, and planning disciplines, as well as academics from different departments. The teams addressed technical challenges, social innovation, and communication aspects to promote sustainable development. They proposed value-driven solutions to address societal problems in this area. The SusTIMEability-lab project improved ongoing activities in participating universities through hackathons, invited lectures and seminars, technical visits, and a public workshop. The project's outcomes impacted education, research, and society. This impact extended beyond the university community to the cities where the universities are located, through the transfer of knowledge.

Keywords: living lab; sustainability; decarbonisation strategies; cooperative learning.

How to cite: Montagud Montalvá,C.; Sanchis Saez,J.; Soriano Olivares,J.; Sapena Bañó, A.; Querol Monforte, A. and Peñalvo López,E. (2024) Living labs and collaborative initiatives on European university campuses for sustainability learning: SusTIMEability-lab project. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 866-874. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In the current climate emergency, engineers play a pivotal role by developing innovative solutions and adaptation and mitigation strategies that can minimise the impact of climate change on society and the environment. In this context, the integration of the United Nations Sustainable Development Goals (SDGs) into engineering education is of paramount importance to foster a generation of professionals with the necessary skills to address the complex challenges of our time (Abo-Khalil, 2024), with a holistic understanding of the interconnectedness between technological innovation, social progress and environmental stewardship, and able to make meaningful contributions to society. Over the last years, many technical universities in the world have made efforts to incorportate and enhance the SDGs in engineering education. Several examples can be found in (University of Toronto, 2023).

Since ETSII is a technical university's industrial engineering school at the Universitat Politècnica de València, it has the mission to create specialized study paths that will help its best students pursue professions abroad with a solid engineering foundation. To do this, it is essential to create sustainable learning opportunities, such as interdisciplinary challenges that let students collaborate in multidisciplinary groups to find solutions to problems that society has requested be addressed in light of the climate emergency. Best-practice case studies, such as living labs and other sustainability learning initiatives on campus (Bossert and Verhoef, 2019), can provide an appropriate context for students to learn about sustainability. This approach utilises the fact that students spend a significant amount of time on campus during their studies. As a result, they have a comprehensive understanding of the areas that require the most attention in terms of sustainability improvement. Additionally, they can identify which solutions are more feasible and have a lower impact on everyday's life on the university campus. In this context, the ETSII aims to enhance its internationalization efforts through a synergistic and multidisciplinary framework. The school has decided to lead a collaborative project titled 'SusTIMEability-lab: Living Labs and Collaborative Initiatives on University Campuses for Sustainability Learning', with two main goals: share different knowledge and learning experiences with other technical schools that have similar goals in sustainability learning, and enhance the incorporation the SDGs into the different eneeering studies.

2. The SusTIMEability lab project

2.1 Project description

The SusTIMEability-lab project is a twelve month duration (February 2023-January 2024) collaborative project financed by the Top International Managers in Engineering (T.I.M.E) association. Its objective is to improve sustainable education through cooperative learning, where students learn by doing. The project was led and hosted by the School of Industrial

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Engineering (ETSII) at the Universitat Politècnica de València (UPV). It is closely related to the key pillars of UPV's Strategic Plan for 2023-2027, including sustainability, internationalization, relevance, vitality, and excellence. The SusTIMEability-lab project involved four institutions: Universitat Politècnica de València (UPV), KTH Royal Institute of Technology (KTH), École Centrale Méditerranée (ECM), and Delft University of Technology (TuDELFT), which provided added value for both academic and research collaboration. These universities are all involved in living lab initiatives and other activities related to sustainability learning. They are located in cities that have been selected by the European Commission to become carbon neutral by 2030 under the EU mission Climate-Neutral and Smart Cities (European Union, 2022). The cities include Valencia, Marseille, Stockholm, and Amsterdam. The main goals and expected outcomes of the project are summarized in the following:

a)Creation of a framework for organizing design projects among students from different universities, in a multidisciplinary approach, with sustainable challenges in perspective.

b) Enhancement of the collaboration between groups of students supervised by professors from different universities on a 'real-world' application problem/challenge, taking advantage of the internationalization of the participating universities (KTH, ECM, TU Delft and UPV) and involving exchange students and professors. A Hackathon or similar competition, consisting of a collaborative event that encourages rapid exchange of ideas, accelerated development and networking with others in a short period of time, took place involving students and professors in the form of multidisciplinary teams to make proposals for the different living lab initiatives for sustainable learning carried out in the different institutions.

c) To strengthen the relationship between professors working under the same common topic: sustainability learning, also promoting future short teaching exchanges for the professors for this topic. The professors from each university gave invited lectures/seminars to the target groups in a hybrid format (in-person and online). The lectures/seminars were held on each campus (KTH, UPV, TU Delft, ECM) and were open to students from other consortium universities as well as all T.I.M.E members who could follow them online. In November 2023, the ETSII at UPV in Valencia hosted a final workshop for the dissemination of results and the establishment of synergies. The workshop was attended by a group of three to five selected students along with one professor from each institution.

d)To serve as a base to continue with new future challenges related to sustainability learning initiatives. The same institutions have submitted a new project under both the Erasmus+ and the T.I.M.E association call for continuing the activities during 2024, which has been funded.

2.2 Target group/s and impact

The SusTIMEability-lab project's impact on its various target groups is analysed in the following text.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

- Academia: this joint T.I.M.E. project between KTH, ECM, TU Delft, and UPV in academia will strengthen networking and add value. The project, SusTIMEability-lab, will have several editions to continue activities beyond the first edition. Furthermore, facilitating interaction between students and their supervisors can significantly increase mobility among institutions, thereby enhancing the efficiency of T.I.M.E. membership.

- Education: this target group pertains to Master's degree students in mechanical, energy, chemical, industrial engineering, building technology, and architecture, as well as academic staff in these fields. Other students, including those involved in double degree programs, may also be affected. The project aims to address a significant gap in teaching decarbonization strategies for buildings and cities. The results could contribute to the development of teaching materials on the topic and provide an excellent opportunity for students to improve their skills and knowledge.

- Research: This project has strengthened networking activities for universities, both within and outside of the T.I.M.E. membership. For example, TU Delft is involved in this project and has shared results and established synergies with others.

- Society: all project activities will involve the final users, who are members of the university community and citizens of the cities where the university campuses are located. The knowledge gained from the SusTIMEability-lab project have been transferred to the cities where the universities are located. Valencia, Marseille, Amsterdam, and Stockholm are among the 100 cities selected by the European Commission to become carbon neutral by 2030 and the professors involved in the project collaborate with the cities by means of R&D&I projects to help them in the decarbonisation process. Therefore, this SusTIMEability-lab project has provided added value by establishing synergies and sharing knowledge to be transferred to the cities as a key element for their decarbonization.

2.3 International multidisciplinary team

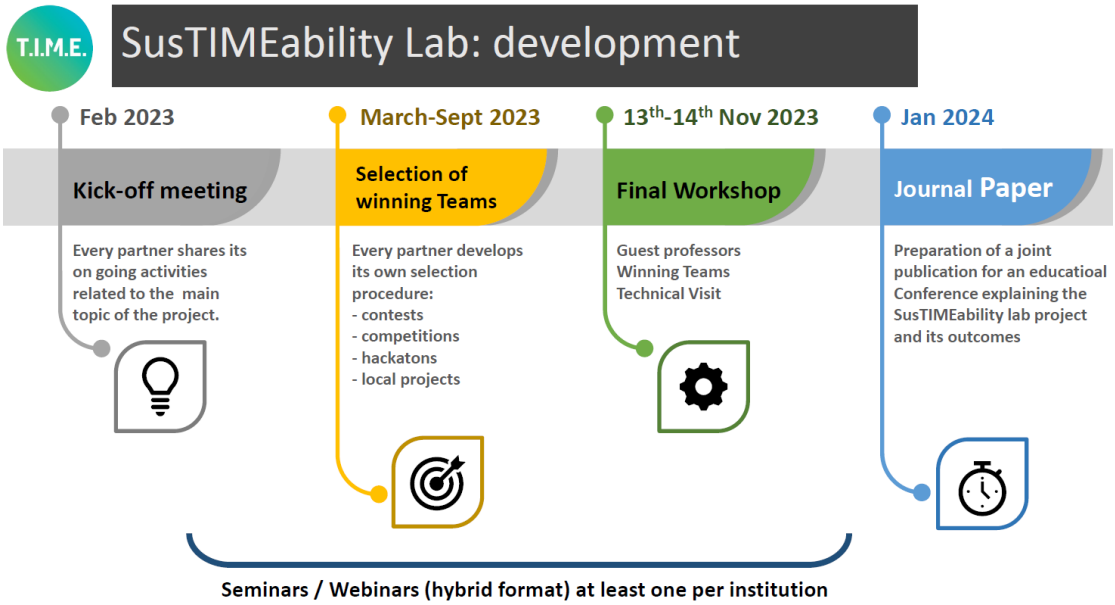
An international multidisciplinary team was created from the very beginning where both professor and students came from different disciplines and had different background and expertise (energy engineering, mechanical engineering, electrical engineering, chemical engineering, computer science, environmental science and architecture and built environment). In addition, the professors involved actively implemented various initiatives and plans to improve the sustainability of their campuses. These included the director of sustainable development at ETSII from UPV, the Vice-president for Sustainability at KTH, the director of the engineering programme at ECM, and the Sustainability Coordinator of TU Delft. This provided a comprehensive understanding of the sustainability strategic plan for various university campuses and the necessary actions to achieve its objectives.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Actions and initiatives carried out

Figure 1 shows a layout of the different planned activities for the project.

Fig. 1 – Planning of activities carried out in the SusTIMEability-lab project.



Source: Escuela Tècnica Superior de Ingeniería Industrial, (2023).

The project began in February 2023 with a kick-off meeting. A roundtable discussion was held with the members of the SusTIMEability-lab project to coordinate the different activities and adjust the activity plan as necessary.It was agreed that each university would conduct a challenge, hackathon, or final presentation related to the topic of the SusTIMEability-lab project between March and early September 2023. The winning team from each university (KTH, TuDELFT, and ECM) travelled to Valencia for the final workshop held in the first semester of 2023-2024. The final workshop featured invited professors as speakers, and students presented their work from the challenge or course conducted at each university. Two to three students from each institution were able to travel with T.I.M.E funds. In terms of seminars and webinars related to living labs or sustainability initiatives, it was proposed that each institution hosted one seminar in a hybrid format that was open to foreign students and/or professors from other institutions to attend online. During the period from March to June 2023, various activities were carried out. On May 4th, the hackathon 'Indushack living lab' was launched as part of the SusTIMEability-lab project. Figure 2a displays an image of the event announcement (Escuela Tècnica Superior de Ingeniería Industrial, 2023). A total of 42 students worked in teams of two or three to propose innovative solutions for improving the sustainability of one building at the ETSII, and reducing its carbon footprint in at least three dimensions: energy, water, waste and circular economy, nature-based solutions in building, and habits of use and social inclusion. When proposing solutions, it was important

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

to quantify how they would improve the building's baseline situation, including both technical and economic feasibility. Additionally, for the academic year 2023-2024, at least one challenge related to any of the above dimensions should be set. As a result, students proposed different solutions to improve the sustainability of the building, mostly focused in reducing the energy and water consumption of the building and waste generation, also improving the air quality and sense of belonging by means of nature based solutions integrated in the building. The objective of this initiative was to serve as a testing ground for innovative solutions that could be transferred to other institutions, such as comparable campus or urban institutional structures to help the decarbonization of cities in the EU mission of 100 smart and climate neutral cities. The chair of Energy Transition in Cities is currently undertaking this initiative, which is financed by the city hall of Valencia. The objective is to replicate this type of action in an institutional building located in Valencia city (La Harinera), which is an old flour factory that has been refurbished and converted into a space that aspires to become the new public entity of public innovation in the city of Valencia.

Fig. 2 – a)Hackathon celebrated at the ETSII,UPV. b) Final workshop of the SusTIMEability-lab project

a) **b)**



Source: Escuela Tècnica Superior de Ingeniería Industrial, (2023).

On the 18th of May, the final took place The winning teams were chosen by a jury composed of professors of the ETSII, and other members of the different institutions that collaborated in the event. The criteria considered to select the winning team were based on the characteristics of the solutions proposed: relevance and originality, impact, techno-economic feasibility, innovation and creativity, how well were environmental and social sustainability addressed and quality and clarity of the results presented. Additionally, the rating might be increased if the solution demonstrated a conscious and effective approach to addressing gender inequalities, and it involved different disciplines or areas of expertise. The winning

BY-NC-SA 2024, Editorial Universitat Politècnica de València

team was selected to visit one of the campuses participating in the T.I.M.E. project. KTH in Stockholm in Sweden, was finally selected. Three students from UPV travelled to Stockholm from 13 to 16 September 2023, to visit the KTH campus and learn about the sustainability actions carried out by KTH. On the afternoon of the 14th, they visited a monitored living lab, and they were able to learn first-hand about different strategies implemented in such facilities and buildings. On Friday 15th September, they attended the final of a competition held by KTH students as part of a master's degree course titled 'Energy Management' at KTH. Nineteen groups of 5-6 students each participated in the competition, proposing decarbonisation plans for 19 different university campuses worldwide. The event was held in a hybrid format, allowing other universities who are members of the SusTIMEability-lab consortium to participate. In relation to ECM, they organised a COP week in June 2023 focused on energy resources and biodiversity. A professor from KTH was invited as a keynote speaker to discuss the energy topic. Each of the other institutions involved in the project carried out a similar activity related to living lab initiatives and sustainability learning on their campuses before the end of October 2023. They were to select up to three students. Table 1 provides a summary of the initiatives undertaken by each university to select students.

Table 1. Summary of the initiatives carried out at each university to select students.

University	Type of activity	Brief description
UPV	Hackathon	Challenge:improve the sustainability of the ETSII and reduce its carbonfootprint.
KTH	Energy management course. Project and competition	Project on how to create a Smart and Sustainable Campus by 2030.
ECM	Competition	Development of innovative technical solutions for decarbonising the cities
TuDELFT	Green TU team	Being part of a student organisation devoted to stimulating sustainability in TuDELFT

Source: Own elaboration

Finally, on the 13th-14th November 2023, a final workshop took place at the ETSII of UPV in Valencia, Spain. A group two to three selected students from each institution, along with one professor from each university attended the workshop. The living lab and sustainability initiatives carried out on each university were presented both by the professors and students, and the details and results of the different events and competitions where they had been selected in each university in the framework of the SusTIMEability lab project. As an example, students from UPV, presented solutions for a more sustainable and inclusive building where the ETSII LivingLab is located, which reducedeat least 25,412 tons of CO_2 per year by using

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

renewable energy (25.01 tons of CO_2 reduction thanks to the installation of 99 kWp of Photovoltaics on the roof), improving insulation and reducing waste (210 kg of waste per year and 404.73 kg of CO_2 annual reduction thanks to modifications to vending machines to avoid packaging) and water consumption (reduction of 82,125 liters/year thanks to modifications in the type of faucets and urinaries using authomatic closing valves and detection sensors). This challenge, of a multidisciplinary nature, was framed in different SDGs: SDG 4, SDG 6, SDG 7, SDG 11, SDG 12 and SDG 13. Additionally, a technical visit to a industrial company near UPV compromised with the sustainable development was organized during the final workshop. Figure 2b shows a picture of the announcing of the event.

4. Conclusions

The main results and contributions of the project have resulted in the establishment of an international collaborative framework where students and professors exchange and gain knowledge on sustainability learning. Within this framework, several initiatives have been carried out: hackathons, technical visits, seminars and a final workshop. The results obtained are transferable to the city through different research and collaboration projects in the framework of the European mission of smart and climate neutral cities for 2030, in which professors are involved. As future lines of action, activities will continue in 2024 with the next funded project titled 'SusTIMEable campus Towards more Sustainable university campuses'.

Acknowledgements

This work was funded by the T.I.M.E association. Authors would like also to thank the school of industrial engineering, ETSII, at the Unviversitat Politècncia de València, who supported and hosted the project activities carried out, and the "Innovación y mejora educativa aplicada a los Objetivos de Desarrollo Sostenible en la ETSII"project (PIME/21-22/281), financed by Vice-Rectorate for Organization of Studies, Quality, Accreditation and Languages of the Universitat Politècnica de València.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Abo-Khalil, A.G., (2024). Integrating Sustainability into Higher Education Challenges and Opportunities for Universities Worldwide, *Heliyon, e29946,* https://doi.org/10.1016/j.heliyon.2024.e29946.

Bossert, M., Verhoef, L.A., (2019). The University Campus as a Living Lab for Sustainability - *A Practitioner's Guide and Handbook.* ISBN: 978-3-940670-68-7.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Escuela Tècnica Superior de Ingeniería Industrial, (2023). Indushack Living Lab 2023, https://www.etsii.upv.es/noticia-es.php?id=1073.

European Union, EU Missions - 100 CLIMATE-NEUTRAL AND SMART CITIES, (2022.) [Online]. Available: https://op.europa.eu/en/publication-detail/-/publication/822ee360-c9bf-11ec-b6f4-01aa75ed71a1/language-en

University of Toronto, (2023). Sustainability Doctoral Thesis Inventory. [Online]. Available: https://sustainability.utoronto.ca/resources/inventories/sustainability-doctoral-thesis-inventory/

2024, Editorial Universitat Politècnica de València BY-NC-SA

Can AI be used to develop an on demand and sustainable feedback system?

Nazim Ali and Sarah Aynsley

School of Medicine, Keele University, UK.

Abstract

The increasing emphasis on student-directed learning approaches such as peer-learning has been recognised as a key factor in enhancing the sustainability of student learning, as it reduces the need for additional staff input. However, a notable limitation of peer-learning is the absence of timely and accurate feedback, crucial for ensuring the correctness of learning. This paper explores the potential of generative artificial intelligence (GAI) powered chatbots, such as ChatGPT and Gemini, to serve as feedback tools in student learning contexts. We hypothesized that GAI's capability to analyse and generate detailed responses could be adapted to provide constructive feedback akin to that of a teacher. To assess this, ChatGPT and Gemini were prompted to evaluate a 'mock' student response to a short answer question based on established marking guidelines. This approach was found to provide constructive and detailed feedback and offer significant advantages, such as real-time feedback, enabling students to assess their learning and identify areas for improvement. These benefits are consistent with existing literature on AI in education, which highlights AI's role in providing personalised and interactive learning opportunities (Rawas 2023). Given these positive initial results, we propose that this GAI-based approach can support students in peer-learning environments, providing detailed feedback in a manner which is autonomous rather than requiring more staff input and thus making this way of learning sustainable. As such a comprehensive study in a real-classroom setting is being undertaken to assess the robustness of this approach and the consistent reliability of the feedback provided.

Keywords: peer-learning ; sustainability; generative-AI; constructive; feedback.

How to cite: Ali, N. and Aynsley, S. (2024) Can AI be used to develop an on demand and sustainable feedback system?. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 875-883.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Student-directed learning (SDL) encompassing a wide range of approaches from Problem Based Learning to Flipped Learning is focused on enabling students to take more responsibility of their learning. This enables students to have autonomy over their learning, particularly in identifying their own learning needs and effective ways of learning. The shift in autonomy and responsibility is argued to drive student engagement leading to enhanced learning (Charokar and Dulloo 2022). Peer-learning represents a form of SDL involving students to be actively engaged in building of knowledge through a collaborative effort. This collaboration encouraging students in sharing of perspectives and challenging of each other's understanding leads to cognitive conflict, a critical element in the cognitive process that fosters enhanced and deeper learning (Dolmans and Schmidt 2006). Aligned to the ethos of SDL, within peer-learning students actively learn from each other, minimizing the need for continuous teacher intervention or direction (Boud et al., 1999), thus making the learning process more sustainable. However, the minimally guided element of peer-learning can be argued as a weakness and warrants considerations to mitigate this. For example it can be rationalised that without the immediate guidance or feedback from a teacher, information exchanged among peers, if not fully correct or substantiated, may lead to compromised learning. Moreover it is recognised that within peer-learning students miss out on the 'feed forward' process i.e suggestions of improvement which is an important aspect of making feedback effective (Hattie and Timperley 2007).

The role of feedback in enhancing student learning is well established and is shown to be most effective when it is specific and timely. However, given that peer learning often takes place without much input from a teacher, the opportunity to provide feedback in a timely manner becomes a logistical issue. Technology is now an integral part of the education system offering greater affordances to enhance teaching and learning. The advancement in Generative Artifical Intelligence (GAI) i.e artificial intelligence which has the ability to synthesise content now provides an opportunity to explore different approaches of enhancing teaching and learning (Su and Yang 2023). GAI-driven platforms can analyze individual learning patterns and tailor content to suit each student's needs, offering a more adaptive and responsive learning experience (Li and Wong 2023). Thus it can be reasoned that GIA can be prompted to analyse student work and provide feedback which is constructive. In doing so this approach with AI technology has the potential to promote equal learning opportunities and make learning personalised.

Technology and technology based tools also offer opportunities to make educational practices sustainable which is paramount in today's rapidly evolving world. Sustainable education promotes lifelong learning, encouraging learners to engage with new ideas and perspectives throughout their lives, thereby fostering a culture of innovation and critical

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

thinking (Wals, 2010, Daniela et al., 2018). Aligned with the SEED Conference theme and recognising peer-learning as a viable option for contributing to the sustainability of education, in this paper we highlight that an inherent weakness of peer-learning is timely teacher feedback to help students improve. As a way of enhancing peer-learning we provide an evaluation of a GIA based feedback generating approach which not only aims to help improve student learning but also make the practice of feedback sustainable. This study undertaken to establish proof of concept of using GAI to develop a sustainable way of generating feedback, is the first phase of a broad project in enhancing and making educational practices such as feedback equitable and sustainable.

2. Methodology

Our overarching aim was to evaluate the pedagogy of using GAI as a feedback tool. We compared the freely available Large Language Models (LLMs), ChatGTP and Google's Gemini to see which one would be best suited for the task. For comparative purpose we used an in-house developed short answer question (SAQ) and its corresponding marking scheme (Table 1) as a test question. Additionally, we formulated a generic mock answer representative of how an average-performing student may answer it. Using the prompt "Mark the student answer on the given question following the given marking guidelines, provide detailed constructive feedback", we fed the mock answer, the SAQ and the marking scheme into ChatGTP and Gemini. The generated feedback is shown in Table 2. Subsequently, we recruited 6 staff members with diverse teaching and assessment experiences from within our department to form a panel to help us undertake the evaluation. For our instrument we used Microsoft Forms. We copied the SAQ, marking scheme, mock student answer and the feedback generated by ChatGTP and Gemini onto it. We also embedded our research questionnaire devised to capture the panel's assessment and opinions on the overall quality and effectiveness of both the feedback. The data were analysed to determine themes, strengths and areas of improvement in our approach of using GAI as a feedback tool.

Table. 1 – The table below shows the short answer question and its corresponding marking scheme used in this study.

SAQ	Marking scheme
A 26-year-old man is currently under investigation for Crohn's disease, a condition caused by excessive inflammation in the gastrointestinal tract. The immune response in Crohn's is driven by T helper 1 cell activation. Explain the steps between a dendritic cell and a naïve T helper cell which will result in Th1 activation. (3 marks)	Award 0.5 marks for each point up to a maximum of 3 The dendritic cell phagocytoses and presents antigen on MHCII The antigen is recognised by the T cell receptor and CD_4 binds to MHCII Co-stimulatory molecules are upregulated on the dendritic cell which bind to the T cell. The co-stimulatory molecules are CD80/86 to CD28 and CD40 to CD40L The dendritic cell then releases IL-12 to polarise the T helper cell to TH1 The T cell will finally release IL-2 to proliferate further

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table. 2 –. To help compare the use of ChatGTP and Gemini as feedback tools, a student representative answer which could benefit from specific feedback was devised and fed into both the systems and prompted to provide constructive feedback. The feedback from ChatGTP and Gemini are also presented in the table.

Student answer: When there is inflammation the body make inflammatory cytokines and there is lots of swelling, T helper cells and dendritic cells come together in lymph nodes. The T cell sees the antigen that the dendritic cell has got. There is some binding between the cells. CD_4 binds MHCII and T Cell receptor to antigen. There is some co-stimulation. The dendritic cell releases a cytokine to tell the T cell to be TH1, this is IL-12. T cells proliferate by making IL-2
ChatGTP Marking and Feedback: The dendritic cell phagocytoses and presents antigen on MHCII (0.5/3). *The student briefly mentions that the T cell sees the antigen presented by the dendritic cell, but there is no explicit mention of phagocytosis. The process of dendritic cell phagocytosing and presenting the antigen on MHCII should be explicitly stated.* The antigen is recognized by the T cell receptor and CD_4 binds to MHCII (0.5/3): *The student mentions the binding between CD_4 and MHCII but does not explicitly state that the T cell receptor recognizes the antigen. A clearer connection between the T cell receptor, CD_4, and MHCII is needed for full credit.* Co-stimulatory molecules are upregulated on the dendritic cell which bind to the T cell (0.5/3): *The student mentions co-stimulation but does not specify the molecules involved (CD80/86 and CD28, CD40, and CD40L). To receive full credit, the student should explicitly mention the upregulation of these co-stimulatory molecules.* The co-stimulatory molecules are CD80/86 to CD28 and CD40 to CD40L (0/3): *The student does not provide specific details about the co-stimulatory molecules involved, which is a crucial aspect of the process. No marks are awarded for this point.* The dendritic cell then releases IL-12 to polarize the T helper cell to TH1 (0.5/3): *The student correctly mentions the release of IL-12 by the dendritic cell, which is necessary for polarizing the T helper cell towards TH1. However, the explanation could be more explicit in connecting IL-12 to TH1 polarization.* The T cell will finally release IL-2 to proliferate further (0/3): *The student mentions IL-2 release by T cells but does not clearly state that it is for proliferation. A more explicit connection between IL-2 and T cell proliferation is needed for full credit.* Overall Feedback: The student provides a basic understanding of the steps between a dendritic cell and a naïve T helper cell but lacks specificity in several key areas. The response could be improved by explicitly stating the process of phagocytosis, recognizing the antigen by the T cell receptor, specifying the co-stimulatory molecules involved, and clearly connecting cytokines like IL-12 to T helper cell polarization. Encourage the student to provide more detailed explanations for each step in the process.
Gemini Marking and Feedback: Marks Awarded: 2.5 out of 3 Strengths: The answer identifies most of the key steps involved in the activation of a naïve T helper cell to TH1 by a dendritic cell: antigen presentation, MHCII-TCR binding, co-stimulation, IL-12 secretion, and IL-2 production. The answer correctly mentions the involvement of CD_4 (binding to MHCII) and T cell receptor in antigen recognition. The answer mentions IL-12 as the cytokine released by the dendritic cell to induce TH1 polarization. Areas for Improvement: Phagocytosis: The answer mentions inflammation but doesn't explicitly state that the dendritic cell phagocytoses the antigen before presenting it. This is a crucial step in antigen processing and presentation. (0.5 mark)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Co-stimulatory molecules: The answer mentions co-stimulation but doesn't provide the specific molecules involved. The marking guidelines explicitly list CD80/86 to CD28 and CD40 to CD40L. (0.5 mark)

Specificity to Crohn's disease: While the question mentions Crohn's disease, the answer focuses on general TH1 activation without explicitly linking it to the specific T cell response in this condition. Mentioning T helper 17 cells (Th17) and their role in Crohn's disease as a contrasting example would have strengthened the answer. (0.5 mark)

Overall Feedback: This is a good attempt at explaining the steps involved in TH1 activation. With some clarification on phagocytosis, specific co-stimulatory molecules, and linking it to Crohn's disease, the answer could achieve full marks. Encourage the student to be more specific in their responses and to draw connections to the provided context.

Additional Tips: Encourage the student to use clear and concise language. Avoid unnecessary phrases like "lots of swelling" and focus on the key scientific concepts.

Diagrams can be helpful in visualizing the process and relationships between different cells and molecules. Encourage the student to consult additional resources to gain a deeper understanding of the immune system and its role in Crohn's disease.

Source: Own elaboration

3. Results

3.1 Identifying factors which influence teachers ability to provide feedback

In rationalising our proposed idea of using GAI as a tool to generate detailed feedback, we first investigated how the task of writing detailed feedback was perceived by our panel of teachers. The majority of the panel members (4 out of 6), in response to the question "How easy is it to write feedback?", responded that they found the task to be challenging or not easy. Key issues such as 1) lack of expertise in giving specific improvement suggestions, 2) time constraints, and 3) the overall labor-intensive nature of the task were perceived to be influencing factors in relation to providing constructive feedback. These findings are consistent with existing research on factors which are perceived to make the process of giving student feedback challenging (Henderson et al., 2019a) and reinforce the importance of our overarching aim of seeking ways to make the process of feedback sustainable.

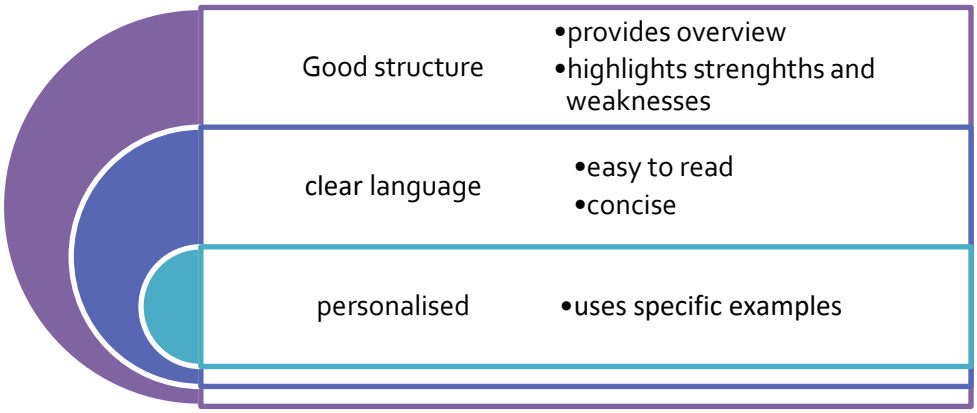
3.2 Evaluation of ChatGTP and Gemini generated feedback and establishing key features which make feedback effective

As LLMs, both ChatGPT and Gemini have the capability to generate content, and we hypothesised that this functionality could be utilised to generate feedback in a way which would help to overcome the challenges of writing constructive feedback. To evaluate this hypothesis, we prompted ChatGPT and Gemini to provide feedback on a 'mock' student's answer and subsequently engaged our panel of markers to assess the feedback from each model. The results showed a clear preference split among the panel members, with half favouring one model over the other in terms of the feedback's constructiveness and its ability to aid student improvement. Despite the difference in preference, analysis of the free text comments revealed that panel members found both of the feedback to be written well, with

BY-NC-SA 2024, Editorial Universitat Politècnica de València

good structure and personalised to help the student improve (Fig 1). Given that these features are important for making feedback effective (Hattie and Timperley 2007), the findings support our idea that GIA have the potential to be used as effective feedback generating tools.

Fig. 1– Common features of the feedback generated by ChatGTP and Gemini. (Figure is derived from the analysis of participants free text comments).



Source: Own elaboration

3.3 Identification of the potential benefits and risks of using GIA as a feedback tool

As part of our evaluation of GAI-generated feedback, we also asked our panel members to share their perceptions of using GAI as a feedback tool. From their responses, four major benefits of using GAI for feedback generation were identified: 1) the ability to provide students with more detailed and specific feedback, 2) the capacity to deliver feedback rapidly, in real-time, 3) the capability to help students identify gaps in their learning and 4) the potential to aid students in effective revision (Fig 2). These benefits are aligned with the growing body of research on AI in education, which suggests that AI tools can offer personalised and interactive learning experiences, enhancing student learning outcomes. Furthermore, AI has the potential to automate administrative tasks, thereby increasing efficiency in educational settings. However, some of the panel also expressed concerns regarding the precision of the feedback generated by GAI, particularly in terms of the system's ability to interpret answers that present unique perspective or differ from standard marking guidelines. This issue has been noted in the literature, where the adaptability of AI systems like LLMs to various linguistic expressions and the nuances in students' writing is acknowledged as a challenge which may influence the reliability of feedback generated by LLMs (Kocon et al., 2023). Despite this concern, almost all the panel members expressed optimism as well as their surprise of the relative ease of using GIA as feedback tools, noting- *"positive experience; its not as scary as I thought :); looking forward to using it".*

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Fig. 2 – Figure shows the key benefits of using GIA as a feedback tool as derived from analysis of participants free text comments.



Source: Own elaboration

4. Discussion

In this exploratory, "proof of concept" study, we investigated the use GAI namely ChatGPT and Gemini as potential feedback generating tools The rationale for this investigation was to develop an autonomous way in which students could receive real-time feedback without necessarily requiring teacher input. For this we conducted a simulated exercise where we generated a mock answer to a standard short answer question and prompted GAI to mark and provide feedback on it. Recruiting staff within our department we formed a panel of markers to evaluate the feedback generated by ChatGPT and Gemini. The panel found that both models generated feedback containing features such as good structure and specific examples of how to improve, which are recognsied to be essential in making feedback constructive (Hattie & Timperley, 2007). Furthermore the autonomous nature of using technology in obtaining feedback by students in a collaborative setting has been reported to increase engagement (Henderson et al., 2019b) and hence we postulate that the approach of using GAI too is likely to ensure the success of the feedback process. Thus, the fast and automated nature of our GAI approach offers the possibility of an on-demand feedback system, enhancing the responsiveness and accessibility of feedback for students. Furthermore, integrating this feedback system within a peer-learning setting holds promise for innovative learning opportunities. Such an approach will maintain a student-directed learning experience with the opportunity for students to assess learning and gain feedback in a self-independent manner. Thus the model aligns with the principles of sustainable education, as it can enable the learning of large student cohorts without necessitating an increase in staff numbers .

However, our analysis also highlighted several important considerations. The preference split among the panel members between ChatGPT and Gemini underscores the subjective nature of feedback evaluation and highlights concerns regarding the reliability and factual accuracy

BY-NC-SA 2024, Editorial Universitat Politècnica de València

of GAI feedback which may stem from inherent bias towards only recognsing one specific type of expression or language style (Nah et al., 2023). Our findings, albeit on a small scale, puts the spotlight on the limitation of current LLMs and their capability of effectively dealing with the gray areas of human expression. To address this, our future research will explore more advanced LLMs like ChatGPT 4.0 and DALLE, which are reported to have enhanced capabilities. We also plan to experiment with different prompting styles and marking guidelines to refine our approach.

In summary, our study contributes to the discourse on the potential role of GAI in overcoming practical barriers to effective feedback provision, such as time constraints and lack of specific expertise. The findings support the proof of concept of using LLMs like ChatGPT and Gemini as tools for generating constructive feedback. With its rapid and autonomous nature, this approach presents a case for contributing to the sustainability of educational practices. Furthermore it puts a strong emphasis on the need of educators to become trained in using AI to be able to improve the assessment and feedback process. However, our research also points to the limitations of current LLMs which need addressing so that AI models can accommodate the diversity of student expressions and ensure the feedback is not only accurate but also meaningful and supportive of student learning objectives.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Boud, D., & Cohen, R., Sampson, J. (1999). Peer learning and assessment. *Assessment & Evaluation in Higher Education.* Vol 24, pp. 413-426. https://doi.org/10.1080/0260293990240405

Charokar, K., & Dulloo, P. (2022). Self-directed Learning Theory to Practice: A Footstep towards the Path of being a Life-long Learner. *J Adv Med Educ Prof.* 10(3): 135–144. doi: 10.30476/JAMP.2022.94833.1609

Cushing, A., Abbott, S., Lothian, D., Hall, A. & Westwood, O.(2011). Peer feedback as an aid to learning – What do we want? Feedback. When do we want it? Now! *Medical Teacher*. Vol, 33, pp e105-e122. https://doi.org/10.3109/0142159X.2011.542522

Daniela, A., Visvizi, A., Gutierrez-Braojos, C., & Lytras M. (2018). Sustainable Higher Education and Technology-Enhanced Learning (TEL). *Sustainability,* 10(11), 3883. https://doi.org/10.3390/su10113883

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Dolmans, D.H., & Schmidt, H.G. (2006). What Do We Know About Cognitive and Motivational Effects of Small Group Tutorials in Problem-Based Learning? *Adv Health Sci Educ Theory Pract* 11, 321–336. https://doi.org/10.1007/s10459-006-9012-8

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, 77(1), 81-112. https://doi.org/10.3102/003465430298487

Henderson, M., Ryan, T., & Philips, M., (2019a). The challenges of feedback in higher education. *Assessment & Evaluation in Higher Education*, Vol 44, pp 1237-1252. https://doi.org/10.1080/02602938.2019.1599815.

Henderson, M., Phillips, M., Ryan, T., Boud, D., Dawson, P., Molloy, E., & Mahoney, P. (2019b). Conditions that enable effective feedback. *Higher Education Research & Development*, *38*(7), 1401–1416. https://doi.org/10.1080/07294360.2019.1657807

Kocon, J., et al., (2023). ChatGPT: Jack of all trades, master of none. *Information Fusion*. Vol.99. https://doi.org/10.1016/j.inffus.2023.101861

Li, K.C, & Wong, B.T.-M. (2023), Artificial intelligence in personalised learning: a bibliometric analysis, *Interactive Technology and Smart Education*, Vol. 20 No. 3, pp. 422-445. https://doi.org/10.1108/ITSE-01-2023-0007

Nah, F. F., Zheng, R., Cai, J., Siau, K., & Chen, L. (2023). Generative AI and ChatGPT: Applications, challenges, and AI-human collaboration. *Journal of Informational Technology Case and Application Research.* Vol 25, pp 277-304. https://doi.org/10.1080/15228053.2023.2233814

Rawas, S. ChatGPT (2023): Empowering lifelong learning in the digital age of higher education. *Educ Inf Technol* . https://doi.org/10.1007/s10639-023-12114-8

Su, J., & Yang, W. (2023). Unlocking the Power of ChatGPT: A Framework for Applying Generative AI in Education. *ECNU Review of Education*,(3), 355-366. https://doi.org/10.1177/20965311231168423

Wals, A.E.J. (2010). Mirroring, Gestaltswitching and Transformative Social Learning: Stepping Stones for Developing Sustainability Competence. *International Journal of Sustainability in Higher Education,* 11(4), 380-390. https://doi.org/10.1108/14676371011077595

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Learning sustainable building *by doing* architectural detail models

Elena Montacchini[a], Angela Lacirignola[a]

[a]Department of Architecture and Design, Politecnico di Torino, Italy

Abstract

The paper presents the outcomes of an experimental didactic activity aimed at developing three-dimensional architectural details models starting from the exploration of "zero cost" materials and products. This activity was proposed to students in the first year of the degree course in Architecture at Politecnico di Torino, as part of the course Culture and Fundamentals of Architectural Technology.

By considering the building as the set of spatial and technical elements characterised by their function and relationships, the process of architectural detail modelmaking allows students to understand the functional roles of the different building components, and to explore how different elements and materials integrate to realize a sustainable and energy-efficient building.

Furthermore, the choice of using waste or recycled materials has brought the students closer to sustainability issues, in particular focusing on material recovery and the circular economy. The students creatively explored the 'zero-cost' materials available to them, selecting those that visually or tactically alligned with the characteristics of the architectural element they intend to model.

The models were collected in a book. The result is an unusual open access catalogue of architectural details easy to understand, made by architecture students for architecture students.

Keywords: architectural technology; technical element models; sustainable building; learning by doing.

How to cite: Montacchini, E.; Lacirignola, A. (2024) Learning sustainable building by doing architectural detail models. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 884-891. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction: hands-on activity and modelmaking as learning tool

In this increasingly digitized world, physical models still play a strategic role in teaching architectural design and architectural technology. There are several benefits: from providing a tactile and interactive experience that helps the creative process flow, to contributing a better understanding of scale and proportion, and enabling exploration of a building's structural systems, components and material.

In several national and international schools of architecture, the hands-on activity of physical prototyping is a well-established and widely practised activity, and the learning-by-doing approach is considered a distinctive element in the teaching process (Paris, 2017).

A learning by doing approach has been adopted for several years by the Architecture Technology research group of the Politecnico di Torino. In collaboration with the Laboratory of Innovative Technological Systems (LaSTIn), the research group conducts many experiences where the development of prototypes plays a key role, intended both as a learning tool and as a research and experimentation tool (Fasano et al., 2023).

However, students generally develop their technology model at the end of their course of study, or even at the time of the dissertation if this is of an experimental nature and uses prototyping as a research tool. Instead, the paper describes an experience that aimed to explore the possibility of introducing architectural modelmaking in the first year as a real learning tool (Eppinger and Ulrich, 2012) (Mayuk and Coşgun, 2020).

Students thus had the opportunity to use the model not only to represent compositional and typological choices, but as a tool to study in an experimental way the features of materials, components and construction systems and their interrelation in the building system. The aim is to train the skills and competences needed to identify the criteria for choosing between alternative technical options during the design phase of a sustainable building, according to a Hands-on Learning Experience approach (Yildirim et al.,2014; Pak and De Smet, 2022).

2. How to build models: an experiential working methodology

The didactic experimental activity aimed at developing three-dimensional models of architectural details is part of the activities we carried out within the Culture and Fundamentals of Architectural Technology course in the first year of the Architecture degree program at Politecnico di Torino. The course intends to provide students with an initial framework of theories, methods and tools useful for understanding and learning how a sustainable building is made.

The course includes lectures on architectural technology, meetings, seminars and practical activities. Meetings and seminars make it possible to collect direct testimonies from designers, companies and experts in the construction sector enabling deeper exploration of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

specific topics by gaining knowledge, skills and experiences. Practical activities, such as visits (virtual and physical) to materials libraries, construction sites and companies, help students to understand material, technological and performance features of building elements, as well as how materials and building components are connected, combining theoretical study with the observation of objects and their manipulation. A series of exercises on the analysis, comprehension and graphical representation of technological systems completes the training course.

In this context, modelmaking of technological details fits in. The idea of assigning this type of exercise, linked to the concepts of learning by doing, arase during at the special moment of the pandemic - when teaching was conducted exclusively remotely - to provide students with the opportunity to engage in a hands-on activity. Working with waste materials, using what you have 'at hand' without the need to buy specific materials, had the advantage of placing all students in the same conditions. Furthermore, the choice to use waste or recycled materials brought students closer to sustainability issues, in particurarly concerning material recovery and the circular economy. Packaging, textile waste, household items, food packaging are materials that are available and accessible to everyone, and can be processed with low-tech technologies that we all have, such as glue, tape, scissors.

The students were asked: to identify a technical element of the building envelope; to creatively explore 'zero-cost' materials available to them, selecting those that visually or tactically aligned with the characteristics of the element to be modelled; to develop a three-dimensional model, on a proportional scale, highlighting materials and components.

Different approaches were employed to develop models, resulting in a wide variety of solutions: all-round, embossed, single-material or prevalent material models, of different sizes. Some students paid particular attention to packaging, graphic composition and model presentation. The exercise was developed individually and independently. During the final exam, the model presentation facilitated discussion on sustainability issues and validated understanding of the functional roles of the different materials and components that characterize the building system and the principles of energy efficiency.

3. Architectural detail models

Each student chose the detail to model from those discussed during theory lessons and graphically explored in previous drawing exercises.

These are the main technical elements of the building envelope that detrmine thermal exchanges with the surrounding environment and therefore the energy efficiency:

– Foundation Systems, in particular ground floor with ventilated cavities;

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

– various alternatives of the Wall Systems (brick wall, dry-built wall, e.g.) and their connections with the Floor Systems;
– Roof Systems with the different technical solutions of flat, green or pitched roofs.

The models were catalogued specifying for each one: the technological system and elements, the different functional layers represented, the size and the list of 'zero cost' materials used.

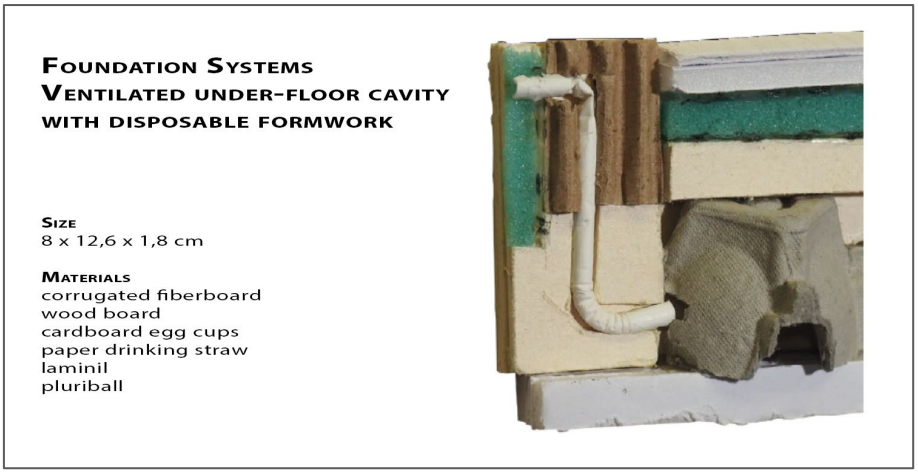
Some of the most commonly used materials were: packaging materials, such as cardboard, bubble wrap, polyethylene sheets; scraps from other modelling activities, such as Laminil or vegetable cardboard cuttings; materials and objects commonly found at home, such as different types of sponges, coffee capsules, gauze, surgical masks, caps, cloth.

These waste materials took on different functions within the various models, depending on the different material interpretations given by the students. For example, dish sponges represented insulation material well, but when appropriately coloured, they also became the substrate of a green roof; egg cups were used as formwork for the ventilated crawl space in the ground floor, but also as a draining layer of the green roof.

3.1 Foundation Systems

The Foundation Systems section encompasses a variety of technological solutions related to the building's connection to the ground. The most frequently represented solution is the ground floor with a ventilated crawl space with disposable formwork. Egg cups, plastic bottle bottoms and biscuit containers were useful waste materials used to represent disposable polypropylene formwork; paper and plastic straws, along with various types of tubes, well represented ventilation pipes for the ventilation of the crawl space; foam rubber and corrugated cardboard were assimilated as insulation materials.

Fig. 1 – Foundation System Model (Card n. 002 - Open Access Catalogue)



Source: Lacirignola and Montacchini, 2023

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3.2 Wall Systems and Floor Systems

The models in this section represent different technological alternatives of external walls and intersection details between the wall systems and floor systems.

Different types of walls were explored: brick walls with external, internal or cavity insulation, x-lam panel walls, wood-framed systems, ventilated facades; combined with traditional brick slab solutions or more innovative steel or x-lam solutions.

Hydrophilic cotton, dish sponges, Plumbers Hemp, all represent insulation materials with different characteristics and density; corrugated cardboard was largely used to represent brick blocks; toothpicks, wooden ice-cream sticks, wire were used as support structures for ventilated facade cladding.

Moreover, in floors, nails and steel wire represented the rebar and various types of tubes were used for the pipes of the underfloor heating system.

Fig. 2 – Wall and Floor System Model (Card n. 36 - Open Access Catalogue)



Source: Lacirignola and Montacchini, 2023

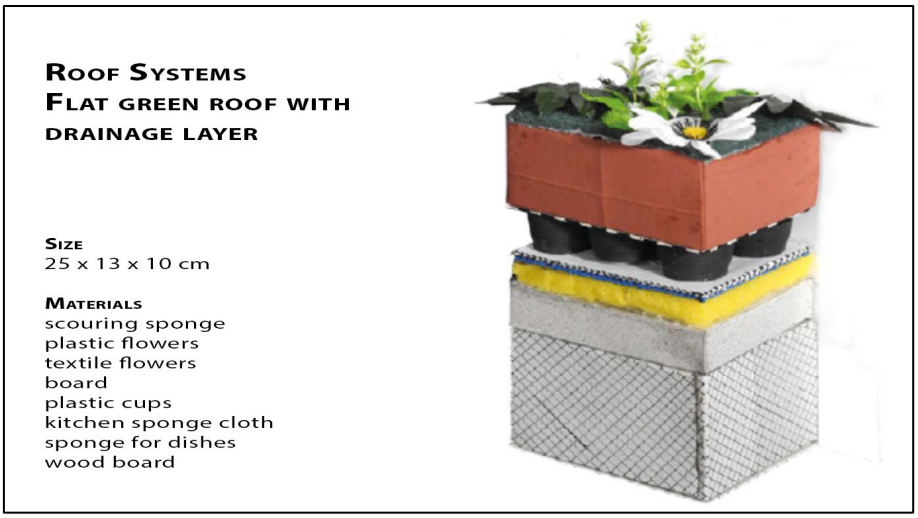
3.3 Roof systems

In the Roof Systems section, the green roof system was the favourite among the students.

For green roofs, students crafted the vegetation layer using dry leaves, stabilised moss, fabric, plastic or paper flowers and leaves. Dish sponges were a useful material for representing the different layers of the green roof technology package; sponges with an abrasive side were used to create the substrate and vegetation with a single material; egg cups, pill blisters, coffee capsules represented the drainage layer; surgical masks rapresented the filtration layer.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig.3 – Roof System Model (Card n. 79 - Open Access Catalogue)

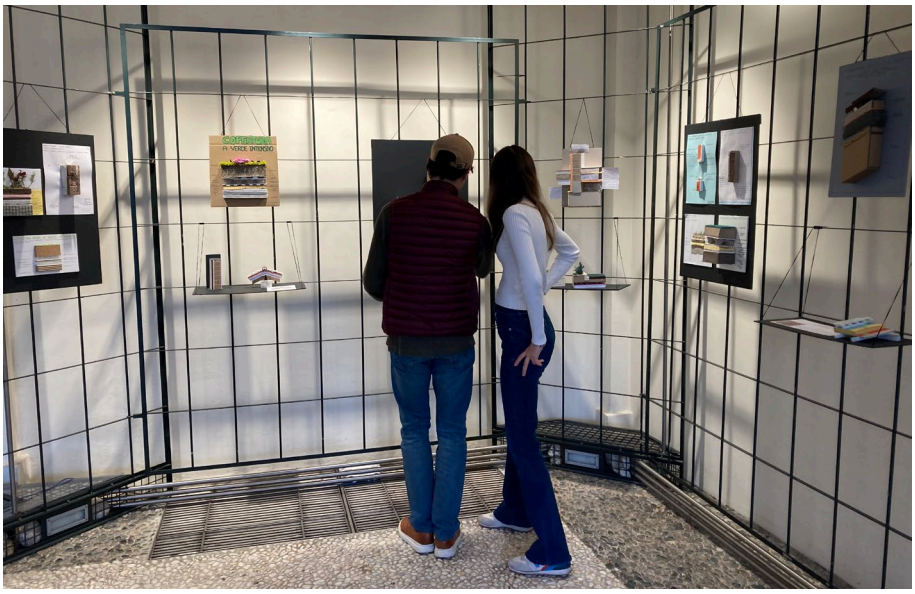


Source: Lacirignola and Montacchini, 2023

4. Results and Conclusion

An exhibition was the first opportunity to present three-dimensional models of architectural details at the School of Architecture. Like the models, the exhibition itself was built at 'zero cost' using recycled materials and waste from previous installations.

Fig.4 – Detail models exhibition



Source: Own elaboration

Then, the presentation of the models in the form of an open-access catalogue [Lacirignola and Montacchini, 2023], made them available as a tool for studying and exploring the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

technical elements of the building and highlighted how it is possible to use waste or recycled materials to make models and understand their function.

The catalogue is annualy expanded with new models and holds an educational and training value for students. Within it they find the suggestion to adopt a working methodology based on the synergetic use of several forms of representation to understand objects and on hands-on experimentation to reinforce theoretical knowledge. Furthermore, it offers a collection that becomes a working tool for understanding the functional roles, layers and components that characterise the main parts of an energy-efficient building.

Thanks to its simple and accessible language, the catalogue serves not only as a learning tool, but also as an informative resource for anyone who wants to approach architectural technology and 'understand' how a building is made.

The experimental didactic activity described in the article, which refers to the learning-by-doing approach associated with the principles of the circular economy, proved useful and interesting and engaged students in understanding the fundamentals of architectural technology in a funny way.

This experience represents a step forward in architecture schools, where this approach is not so obvious and widespread and where students generally do not find many opportunities in the educational curriculum to challenge with in-field learning.

Overall, this is a methodology that can be replicated in other contexts, not only in architecture schools and not only in higher education, because it is able to combine learning, practical approach and even a little creativity. A way to bring the younger generation closer to the themes of circular economy and sustainability.

Acknowledgements

Thanks to all the students who supported us in this experimental didactic activity.

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Fasano, C., Montacchini, E. & Tedesco, S. (2023). Circular economy experiential learning in a domestic lab. From coffee grounds to coffee boards. In *20 Architectural Experiences* (pp. 21-21). Editura Universitara Ion Mincu. https://hdl.handle.net/11583/2983670

2024, Editorial Universitat Politècnica de València BY-NC-SA

Lacirignola, A., & Montacchini, E. (2023). 100 MODELLI 3Di Di nodi tecnologici Di materiali di scarto Di studenti di architettura. https://doi.org/10.57623/979-12-5953-090-5

Mayuk, S. G., & Coşgun, N. (2020). Learning by doing in architecture education: Building science course example. *International Journal of Education in Architecture and Design*, *1*(1), 2-15.

PaK, B., & De Smet, A. (2022). Experiential Learning in Architectural Education, Design-build and Live Projects, Routledge.

Paris, S. (2017). Il rinnovamento della cultura tecnologica nel progetto, tra nuova tettonica e tecnologie digitali. Scenari internazionali dell'insegnamento e della ricerca. *Technè*, *13*(13), 194-203. https://hdl.handle.net/11573/1097315

Ulrich, K. T., & Eppinger, S. D. (2012). Product design and development. McGraw-hill.

Yildirim, S. G., Baur, S. W., & LaBoube, R. A. (2014, September). Fundamentals of framing construction in architectural engineering; a hands-on learning experience. In *2014 Midwest Section Conference of the American Society for Engineering Education,* Sept (pp. 24-26).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Development and sustainment in an Australian education context: Centring Indigenous Knowledges

Gabrielle Murray[a]

[a]Office of Indigenous Education, Research and Engagement, RMIT University, Australia

Abstract

This paper uses an Australia context for a discussion of development and sustainment in education. Learning about Aboriginal and Torres Strait Islander peoples' history, perspectives and worldviews have been a required component of the Australian education landscape since the 1980's (NSW AEP, 1982); however, the hegemony of the colonizer's influence means that western knowledge still dominates, resulting in missed opportunities to learn from 65,000 years of Aboriginal and Torres Strait Islander peoples' knowledge and experience. Through the *Universities Australia accord* process (2022-2023), the Australian Government has completed the most in depth review of tertiary education it has ever undertaken, releasing its final report in February 2024. This paper reviews the *Australian Universities Accord Final Report* (Australian Government, 2024) noting its focus on economic and social development and the lack of attention given to environmental sustainability. Furthermore, it poses that we have much to learn from Aboriginal and Torres Strait Islander peoples' knowledges systems about sustainment.

Keywords: Australian education; Indigenous knowledges; sustainable development; regenerative education.

How to cite: Murray, G (2024) Development and sustainment in an Australian education context: Centring Indigenous Knowledges. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 892-898. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The World Commission on Environment and Development introduced the concept of sustainable development in *Our Common Future* (1987) and defined the term as, 'development that meets the needs of the present without compromising the ability of future generations to meet their needs'. Subsequently, education was viewed as both a framework for and driver of sustainable development. Education was tasked with the job of fostering learners' cognitive, socio-emotional and behaviour competencies (Li and Shein, 2023), as well as delivering the necessary knowledge and capabilities required to understand sustainability issues and develop solutions. Thus, the United Nations Education, Scientific and Cultural Organization (UNESCO, 2017) introduced the term 'education for sustainable development' (ESD). At the begin of the United Nation's (UN) Decade of Education for Sustainable Development 2005-2014, Jenkins and Jenkins (2005) observed that the 'holistic value-laden action-orientated nature of ESD, viewed as essential to generate…positive outcomes, [was] quite radical given…current pedagogical practice'. It is still a radical proposition given the inflexibility of most western education systems. In a neo-liberal environment where education needs to produce profits, often at the expense of the wellbeing of learners and teachers, and of learning for its own sake, education systems generally support the status quo (Reid, 2019).

This paper uses the Australia context for a discussion of development and sustainment in education. Learning about Aboriginal and Torres Strait Islander peoples' history, perspectives and worldviews have been a required component of the Australian education landscape since the 1980's (NSW AEP, 1982); however, the hegemony of the colonizer's influence means that western knowledge still dominates, resulting in missed opportunities to learn from 65,000 years of Aboriginal and Torres Strait Islander peoples' knowledge systems. Through the *Universities Australia accord* process (2022-2023), the Australian Government has completed the most in depth review of tertiary education it has ever undertaken, releasing its final report in February 2024. This paper reviews the *Australian Universities Accord Final Report* (Australian Government, 2024) noting its lack of focus on environmental sustainability; furthermore, it poses that we have much to learn from Aboriginal and Torres Strait Islander peoples' knowledges and practices that have ensured their sustainment with their land.

2. Global Warning – an Australian context

In a discussion about ESD, Jenkins and Jenkins (2005) argued that the three pillars of economy, society and environment posed a challenge of balance whereby international corporations and developed nations failed to consider the effects on smaller and less developed nations. A current example of this can be seen in relation to Australia and its Pacific neighbours, such as the low-lying atoll nations Kiribati and Tuvalu. Morgan (2023) notes that

BY-NC-SA 2024, Editorial Universitat Politècnica de València

rising sea-levels, the increasing ferocity of cyclones and marine heatwaves, and higher levels of acidity in the oceans 'pose existential threats to many Pacific islands'. In its continual drive for economic wealth through major exports of fossil fuels and as a heavy, domestic emitter of greenhouse gases, Australia is a major contributor to global warming (Moss et al., 2023). Holding the position of the World's 14th highest admitter of greenhouse gases (Commonwealth Scientific and Industrial Research Organisation, CSIRO, 2024), Australia's response to its Pacific neighbours has been ambiguously future focused with announcements of a general willingness to accept 'climate change refuges' when the need becomes an imperative (Amnesty International, 2022).

The Morrison Government (2018-2022) went so far as to withdraw Australia from the Green Climate Fund, the world's largest global climate endowment, established as part of the Paris Agreement in 2015 (Morgan, 2023). A recent change in government has seen Australia re-join the fund and declare its willingness to assist locally led, small-scale projects that support 'climate adaptation, disaster preparedness and nature-based solutions' (Morgan, 2023). There has been no such commitment, however, to the World Bank's global initiative, the Loss and Damage Fund, which requires countries such as Australia to pay reparation for the damages they have caused.

2.1. Australian education in review

Education ranks as Australia's third largest export, with iron ore ranked first, and coal, second. (Australian Government, 2015). Historically, education, as an important resource has not been graced with the same political and public support, as has the finite get tangible resources of iron ore and coal. Globally education has become market driven and increasingly expensive, with research and development funding precarious. Through the Universities Australia accord process, the Australian Government undertook an extension review in collaboration with the nation's universities and vocational education institutions. In response to this 'era of profound intellectual, technological, economic and cultural change, in which complacency is dangerous and our egalitarian values need to be defended and renewed', the Australian Government (2023) has proposed education as a possible saviour.

A primary driver of the review is the gap in the number of skilled graduates Australia is producing and the need for workers for current and future industries. The Organization for Economic Cooperation and Development's (OECD, 2016) skills assessment rankings suggest that this is a concern being experienced by many countries across the world to differing degrees. In Australia, the skills shortages are primarily in the areas of health, education, IT, engineering and new emerging industries. Oxford Economics Australia analysis suggests that by 2052, Australia will require an additional '5.8 million people with higher education

2024, Editorial Universitat Politècnica de València BY-NC-SA

qualifications', and the demand for higher education graduates with increase from 36% to 55% of all jobs (Australian Government, 2023).

It is reassuring that the final report notes that tertiary education is vital to Australia's future, positing that the 'knowledge, skills and research it produces' will enable the nation to be ' an economically prosperous, socially equitable and environmentally sustainable nation'. Curiously, in the 408 pages of the final report, sustainable development is never mentioned and 'environmental sustainability' is only mentioned a handful of times, and only then after a repeated phrase about driving 'economic and social development'. Here again we are reminded of Jenkins and Jenkins' (2005) warning about the unequal balance of the three pillars of ESD, with the environment rarely being privileged. In the context of Australian, economic and social development are prioritised in the name of development and growth.

One of the primary claims of the final report is that Aboriginal and Torres Strait Islander students, communities, culture, knowledges, and research will be at the heart of the Australia's tertiary education system. Firstly, through removing barriers to participation for families and communities, enhancing pathways and developing opportunities for transition, and secondly, by including Indigenous knowledges, practices and research into the 'fabric' of Australian education. Recommendation 27, of 47, includes elevating First Peoples knowledge and knowledge system through Leadership to the National Science and Research Priorities. Considering most Australians voted 'No' to a constitutional voice for Indigenous Australians in last year's national referendum (Maguire, 2023), it seems unlikely that the centring of Aboriginal and Torres Strait Islander Peoples in the nation's education system will eventuate without greater bipartisan cohesion around this issue – and a greater understanding of what is at stake here.

3. The Sustainment – *or the challenge of development*

It is hard to imagine how Australia will meet it greenhouse gas emission targets, or that the targets are low enough to stop global warming, let alone create a vision of a tertiary education system that will foster learners' knowledge and the capabilities required for a sustainable future when there is so little discussion of the current state of affairs. We are living in an environment where bush fires are catastrophic and flooding, coral bleaching and fish kills are regular occurrences. On some levels we can be forgiven, as the language of public discourse around global warming and species extinction has been subverted into the benign language of climate change (Harrabin, 2023). Compounding this situation is the fact that Australia, as a nation, does not have a strong history of reconciling with the truth, having not yet dealt with its only bloody, colonial past (Birch, 2002).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fry's (2019) definition of 'the Sustainment' is useful in thinking about the lack of balance between development and sustainability that Jenkens and Jenkens (2005) highlighted more than two decades ago. Fry (2019) argues that sustainability represents 'a post-Enlightenment intellectual project and agenda to deal with 'the world' that modernity, the Enlightenment and the linked 'dark colonial underside' brought into being. Although we are living in the Anthropocene, we seem unable to accept that continued development is leading to our demise; in other words, 'unsustainability'. In Fry's (2019) words sustainment requires us to think the unimaginable; he points out that Indigenous ontologies, 'generally marginalised in the Eurocentric bias of sustainable development debates' may offer 'cosmological and ontological differences' worth investigation and consideration. To give representation to Aboriginal and Torres Strait Islander peoples' experience of sustainment, we need only consider a timeline of the human occupation of Australia of more than 65,000 years. Then consider the damage European colonizers have wrought on the Australian environment in a little more than 200 years.

4. Conclusion

At the COP28 UN Climate Change Conference in Dubai in December 2023, the role of Indigenous knowledges in the climate crisis became central to the discussion, with representatives of the Indigenous Forum advocating for Indigenous knowledges to be recognised as a solution to climate change. Both locally and globally, there is growing recognition of the potential of Indigenous knowledges to inform regenerative practices. In New Zealand (Aotearoa), Canada and some areas of the United States, Indigenous knowledges are now being included in education due to their ability to address the 'everyday challenges of human survival' (Sefa Dei, 2011).

In the Australian context, there are clear examples of how Aboriginal and Torres Strait Islander peoples' knowledges can reduce environmental destruction and greenhouse gas emissions. See for example the work of Russell-Smith et al., (2013) who demonstrate this through implementing Indigenous fire knowledges, grassland management and drought resilience. Another example is the long running Mala Conservation Program which combines traditional Aboriginal knowledge with modern scientific research methodology to save endangered species for extinction. There are also numerous approaches to biodiversity informed by Indigenous knowledges about native foods and medicines (Cumpston, 2020). Currently these activities are happening on the periphery of research and education development. The Australian Universities Accord process is an opportunity to revision the education systems as open to the diversity of knowledges that Aboriginal and Torres Strait Islander cultures have to offer, especially around environmental sustainment.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The author declares that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Amnesty International, Climate Justice, Australia (2022). Paul and Pabai are at risk of becoming Australia's First climate refugees. (W4R 2022). 22 November 2022. https://www.amnesty.org.au/paul-and-pabai-are-at-risk-of-becoming-australias-first-climate-refugees-the-impact-of-the-climate-crisis-on-first-nations-communities-w4r-2022/?cn=trd&mc=click&pli=23501504&PluID=0&ord={timestamp}&gclid=CjoKCQiA5fetBhC9ARIsAP1UMgFLiWtgKlzyqbJpW8uETR_1GXB2ybsUu3etBZB4ruKXEnsnIb-ZsLcaAs1TEALw_wcB

Australian Government. (2023). *Australian Universities Accord Final Report*.

https://www.education.gov.au/australian-universities-accord/resources/final-report

Australian Government, Department of Education and Training. (2015). *The value of international education to Australia.* Commonwealth of Australia. Chrome extension://efaidnbmnnnibpcajpcglclefindmkaj/https://internationaleducation.gov.au/research/research-papers/Documents/ValueInternationalEd.pdf.

Birch, T. (2002). 'History is never bloodless': Getting it wrong after one hundred years of federation. *Australian Historical Studies, 33*(118), 42-53. https://doi.org/10.1080/10314610208596178.

Commonwealth Scientific and Industrial Research Organisation, CSIRO. (2024). What are the sources of carbon dioxide in the atmosphere? https://www.csiro.au/en/research/environmental-impacts/climate-change/climate-change-qa/sources-of-co2

Cumpston, Z. (2020). Food, tools and medicine: 5 native plants that illuminate deep Aboriginal knowledge. *The Conversation*. https://theconversation.com/food-tools-and-medicine-5-native-plants-that-illuminate-deep-aboriginal-knowledge-145240

Sefa Dei, G. (2011). Indigenous philosophies and critical education: A reader. New York: Peter Lang.

Fry, T. (2019) Starting at the End: A Journey in Time. *Journal of Futures Studies, 23*(4), p 159-164. http://doi:10.6531/JFS.201906_23(4).0018.

Harrabin, R. (2023). Does the way we talk about the climate crisis numb people with fear, rather than energise them? *The Guardian, 27 Nov 2023.* https://www.theguardian.com/commentisfree/2023/nov/27/talk-about-climate-crisis-voterslabour#:~:text=Some%20(including%20the%20Guardian%20but,now%20tormenting%20people%20and%20nature.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Jenkins, K. A. & Jenkins, B. A. (2005) Education for Sustainable Development and the Question of Balance: Lessons from the Pacific. *Current Issues in Comparative Education*, 7 (2), 114-129. https://hdl.handle.net/1959.11/326.

Li, W-T. & Shein, P S. (2023). Developing sense of place through a place-based Indigenous education or sustainable development curriculum. Environmental Education Research, 29(5), 692-714. https://doi.org/10.1080/13504622.2022.2098933.

Maguire, A. (2023). Explainer: Australia has voted against an Indigenous Voice to Parliament. *The Conversation.* (15 October, 2023). https://theconversation.com/explainer-australia-has-voted-against-an-indigenous-voice-to-parliament-heres-what-happened-215155.

Morgan, W. (2023). Helping the pacific financially is a great start – but Australia must act on the root cause of the climate crisis. *Climate Council.* (8th Dec 2023) https://www.climatecouncil.org.au/helping-the-pacific-financially-is-a-great-start-but-australia-must-act-on-the-root-cause-of-the-climate-crisis/

Moss, J., Tran, D. & Lee, J. (2023). *If you break it, fix it: Australia's global obligations for a just climate transition*. Oxfam Australia & University of New South Wales. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://climatejustice.co/wp-content/uploads/2023/11/13970-Climate-Just-Transition-Report-WEB.pdf.

Organization for Economic Cooperation and Development (2016) Getting Skills Right: Assessing and Anticipating Changing Skill needs. https://doi.org/10.1787/9789264252073-en

Reid, A. (2019) *Changing Australian education: How policy is taking us backwards and what can be done about it.* Routledge.

Russell-Smith, J., Cook, G.D., Cooke, P. M., Edwards, A. C. Lendrum, M., Meyer, C. P. & Whitehead, P.J. (2013) Managing fire regimes in north Australian savannas: applying Aboriginal approaches to contemporary global problems. *Frontiers in Ecology and the Environment*. *11*(1). https://doi.org/10.1890/120251open_in_new

UNESCO. (2017). *Education for sustainable development goals learning objectives.* Paris: UNESCO.

World Commission on Environment and Development. (1987). *Our Common Future.* Oxford University Press. https://theconversation.com/food-tools-and-medicine-5-native-plants-that-illuminate-deep-aboriginal-knowledge-145240

2024, Editorial Universitat Politècnica de València BY-NC-SA

Principles guiding a South-South capacity development teaching collaboration

Monique Keevy[a]

[a]Department of Accountancy, University of Johannesburg, South Africa

Abstract

In recent years, there has been a significant increase in the number of capacity development collaborations between institutions in the North (partners) with those in the South (recipients). Despite the proliferation of collaborations, there is little empirical research on South-South relationships. Moreover, research collaborations appear more widespread. Capacity development of recipient educators is key to the acquisition of teaching capacities required for higher education to contribute to society. This study, therefore, examines recipient educators' perceptions of the importance of principles that should guide a South-South teaching collaboration. The study employs a mixed method methodology by distributing a questionnaire to educators in two developing countries involved in a South-South teaching collaboration with the same partner institution. Educators indicated that communication is the most important principle, followed by sustainability and ongoing feedback and adjustment. Furthermore, the study highlights several other principles that are important, including, *inter alia,* reciprocal accountability, long-term commitment, flexibility, independence, complementarity, partnership, mutual benefit, relationship between equals, joint ownership, autonomy and shared control. The study also cautions against generating dependency during South-South teaching collaborations.

Keywords: Capacity development; teaching collaboration; South-South; teaching linkages; higher education.

How to cite: Keevy, M. (2024) Principles guiding a South-South capacity development teaching collaboration. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 899-907. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Capacity development emerged as a concept in the late 1980s, after decades of development interventions between nations in the North and the South (Lusthaus et al., 1999; Vincent-Lancrin, 2007). In the developmental literature, the North represents developed countries, such as North America, Europe, Japan, Australia and New Zealand, while the South denotes emerging or developing countries such as in Africa, Asia and Latin America (Wan & Sirat, 2018; Adriansen & Madsen, 2019). Prior to this, the conceptual predecessors to capacity development were 'institution building', 'institution strengthening', 'development management', 'technical assistance' and 'human resources (HR) management' (Lusthaus et al., 1999; Lopes & Theisohn, 2003). Capacity development emerged as an aggregate of these concepts above (Lusthaus et al., 1999; Vallejo & Wehn, 2016), as a shift was required to more sustainable, long-term, comprehensive and independent development interventions (Lopes & Theisohn, 2003; Vincent-Lancrin, 2007). Moreover, the former development approaches were often disconnected from local priorities, ignored local realities, and provided a one-size-fits-all approach (United Nations Development Programme (UNDP), 2009).

The current development model – capacity development – is said to be a local, endogenous process (Pearson, 2011; Adriansen & Madsen, 2019) which strengthens existing local capacities that have been tailored to specific contexts (UNDP, 2009; Färnman et al., 2016). Recipients of the capacity development relationship should, for example, identify their own needs, and interventions should accordingly be customised (Vincent-Lancrin, 2007). Building on local capacities is also more sustainable (UNDP, 2009), as it assists in not creating dependency (Eade, 1997; Vincent-Lancrin, 2007). The change in capacity development from previous developmental models can best be illustrated through the well-known proverb

> give someone a fish and he eats for a day; teach someone to fish, and he can feed himself for a lifetime (Vincent-Lancrin, 2007, p. 53).

In recent years, there has been a significant increase in the number of capacity development collaborations between African universities and foreign institutions. Whitaker (2004) reports 152 collaborations between 2002 and 2003 involving HEIs in the United States (US) and South Africa. Collaborations can take place through various platforms, such as joint research, academic exchanges, joint conferences, technical assistance, knowledge sharing, academic development or teaching and curriculum development (Pearson, 2011). Despite the proliferation of collaborations, especially between North and South, there is little empirical research on teaching collaborations. Most of the studies on collaborations between North-South institutions (Färnman et al., 2016; Owusu-Nimo & Boshoff, 2017), or South-South institutions (Boshoff, 2010; Färnman et al., 2016), have a research focus. Research on teaching collaborations is, therefore, timely and important.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Notwithstanding the increase of collaborations globally (Whitaker, 2004), this matter is largely explored from the perspective of recipients (the educators). Capacity development of recipient educators is key to the acquisition of teaching capacities required for higher education to contribute to society (Robson, 2017). Positioning capacity development from the view of the recipients has the potential to inform social change (Pearson, 2011). The objective of this study is, therefore, to investigate the importance of principles that should guide a South-South teaching collaboration between partners and recipients.

2. Literature review

Higher education institutions (HEIs) generally want to collaborate with international, rather than local or regional, partners (Chaturvedi, 2016; Owusu-Nimo & Boshoff, 2017). In particular, African universities perceive collaborations between North and South as key to capacity development (Pearson, 2011; Ishengoma, 2016; Adriansen & Madsen, 2019). Even though the relationships do contribute to capacity development, South-South collaborations are equally important, as capacities exist in developing countries (Were et al., 2019). It is not always necessary to import these from the North (Lopes & Theisohn, 2003; Färnman et al., 2016). Developing countries can instead "tap into possible synergies" with other developing countries (Chaturvedi, 2016, p. 3). By leveraging on existing resources within developing countries, the human capital of educators can be developed (Chaturvedi, 2016).

This study employs a South-South, rather than the more dominant North-South, relationship (Ofir, 2021). The former is considered more complementary (United Nations Office for South-South Cooperation (UNOSSC), 2019), while the latter represents "a union of unequals" (Altbach, 2004, p. 17), often dictated by the agenda of the North (Adriansen & Madsen, 2019). North-South is also referred to as an asymmetrical (Ofir, 2021) or unbalanced relationship (Boshoff, 2010). Ishengoma (2016), for example, argues that HEIs in the South have little to offer institutions in the North in terms of financial, human or technological resources. This sentiment is echoed by Enders (2007), who conveys that the North does not perceive the South on equal terms.

South-South relationships are characterised as cooperative development between developing countries (Wan & Sirat, 2018), guided by independence, equality, non-interference, mutual benefit and growth (Chaturvedi, 2016; UNOSSC, 2019). South-South relationships provide developing countries with the opportunity to pursue their "capacity development objectives through exchanges of knowledge, skills, resources and technical know-how" (UNOSSC, 2019, p. 6). It can take place in academia or the private sector, between individuals or organisations, within regions or across borders. Ultimately it is for individual and/or mutual benefit (UNOSSC).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

3. Research method

The study employed a mixed-method (quantitative and qualitative) methodology to explore the views of educators at two HEIs involved in a South-South teaching collaboration. Two HEIs were purposively selected, given their similarities, including:

- Both HEIs are engaged in South-South teaching collaboration with the same partner.
- Both HEIs are in developing countries in Africa (Namibia and South Africa).
- Both HEIs are involved in a professional academic programme (within the accounting discipline).
- Both HEIs are public HEIs.

The aim of the capacity development collaborations for both HEIs (as set out in the Memorandum of Associations (MoA)) was to support capacity development of recipient educators and, ultimately, to contribute to the growth and transformation of the demographic composition of the accounting profession.

To gather data on participants' perceptions, a questionnaire was administered to recipient educators involved in the South-South teaching collaboration. Section 1 of the questionnaire sought demographic information. Section 2 comprised 15 closed Likert-scale questions ranging from 1 (not important at all) to 5 (extremely important). Section 2 also allowed participants to comment on the principles in the Likert-scale questions and/or provide additional principles that should guide a South-South teaching collaboration.

The questionnaire was distributed to 27 participants, 13 from Namibia and 14 from South Africa. In total, 24 respondents completed the questionnaire, 12 from Namibia and 12 from South Africa, giving a response rate of 89%. Participation in the questionnaire was voluntary and anonymous in accordance with the ethical approval requirements. The results from the closed questions were analysed using SPSS. Responses to the open-ended questions were analysed using Atlas Ti where recurring synonyms and phrases were used to identify key themes.

4. Empirical findings and discussion

Table 1 is ranked according to mean, from highest to lowest. All principles in Table 1 scored a median of four and above, barring 'dependency'. Thus, educators largely felt that all principles were important to the South-South teaching collaboration. Several open-ended comments also share this view (Respondents 6 & 13), and are illustrated below:

> The aspects above covers adequately the relationship between employer [partner] and employee [recipient] in capacity development. (Respondent 23)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

> The criteria are the building blocks for excellent capacity development relationships. (Respondent 5)

The most important principle indicated by educators, according to the mean scores, was 'effective communication', followed by 'sustainability', and 'ongoing feedback and adjustment'. The majority of respondents also indicated these aspects as being 'extremely important'.

Table 1 – Principles guiding a South-South teaching collaboration

(*n* = 24)	1	2	3	4	5	Mean	Median
Effective communication	0,0%	0,0%	0,0%	16,7%	83,3%	4,83	5,00
Sustainability	0,0%	0,0%	4,2%	20,8%	75,0%	4,71	5,00
Ongoing feedback and adjustment	0,0%	0,0%	8,3%	20,8%	70,8%	4,63	5,00
Reciprocal accountability	0,0%	4,2%	4,2%	33,3%	58,3%	4,46	5,00
Long-term commitment	0,0%	0,0%	4,2%	45,8%	50,0%	4,46	4,50
Flexibility	0,0%	0,0%	12,5%	33,3%	54,2%	4,42	5,00
Independence	0,0%	0,0%	12,5%	37,5%	50,0%	4,38	4,50
Complementarity	0,0%	0,0%	12,5%	41,7%	45,8%	4,33	4,00
Partnership	0,0%	0,0%	12,5%	41,7%	45,8%	4,33	4,00
Mutual benefit	0,0%	0,0%	16,7%	41,7%	41,7%	4,25	4,00
Relationship between equals	0,0%	0,0%	25,0%	29,2%	45,8%	4,21	4,00
Joint ownership	0,0%	8,3%	12,5%	45,8%	33,3%	4,04	4,00
Autonomy	4,2%	8,3%	16,7%	54,2%	16,7%	3,71	4,00
Shared control	4,2%	8,3%	25,0%	37,5%	25,0%	3,71	4,00
Dependency	4,2%	16,7%	41,7%	29,2%	8,3%	3,21	3,00

Source: Author's analysis

Respondents remarked on the importance of effective communication in the open-ended comments, by conveying that there should be "constant communication between stakeholders on shared experiences" (Respondent 10). Furthermore,

> I found that effective and timely communication was key in the capacity building process. (Respondent 12)

> The notion of effective communication and ongoing feedback is critical in order to gauge whether the set objectives of the mutual agreement have been achieved.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

> Without such, where would we be able to measure whether the objectives are achieved? (Respondent 13)

Added to these views, one recipient educator detailed an important area of communication, by mentioning 'reflection and articulation' as a principle required in the collaboration.

> The practice of critical reflection and articulation. This is an exercise designed to explore and/or interpret events we have participated in or observed, and to consciously draw learning or insights from them. (Respondent 10)

The aspect of 'mutual benefits' (mean = 4,25) was indicated as important or extremely important by 41.7% of respondents. Moreover, this aspect received attention in the open-ended comment**s**, as illustrated below.

> It is important to empower academics at both institutions so that partnerships are mutually beneficial without creating a hierarchical relationship or over dependency on the part of some educators. (Respondent 7)

> It is important that the relationship is a give-and-take agreement. Educators from the 'helped' institution should not expect the 'helping' institution to give everything on a plate to them without taking the necessary responsibility. (Respondent 8)

In line with mutual benefits**,** a recipient educator discussed the exit strategy for capacity development.

> Although capacity development should be a long-term commitment, there should be an 'exit' strategy as well. Clearly defined goals and requirements need to be communicated by each party, in order to retain the mutually beneficial agreement. (Respondent 9)

Even though there should be an exit strategy (Eade, 1997), "a follow up is necessary between the two institutions in ensuring" that capacity development "is working after the engagement" (Respondent 14). Akin to these sentiments of an exit strategy, the least important aspect in Table 1 was dependency (mean = 3.21). The literature also explains that capacity development should be cautious about generating dependency (Eade, 1997; Vincent-Lancrin, 2007). This viewpoint was also shared by a respondent.

> Ultimately, once certain criteria are met, the agreement comes to a natural end. (Respondent 9)

Additional important aspects mentioned across educators in a South-South teaching collaboration were relayed in the open-ended question, including motivation (Respondent 21), willingness to share ideas (Respondent 6), mutual respect (Respondent 6), and a relationship of trust (Respondent 10).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Finally, all the principles set out in Table 1 (barring dependency), and the additional principles noted by recipient educators, are the building blocks for a "cohesive capacity development approach" (Respondent 16). All parties in the collaboration should acknowledge these aspects, and the MoA should "clearly define the boundaries of what capacity building areas that needs to be covered and for what period, what actions to be taken when the learning does not take place" (Respondent 17).

5. Conclusions, limitations and areas for future research

The objective of this study was to investigate the importance of principles that should guide a South-South teaching collaboration. This study found that the all principles – effective communication, sustainability, ongoing feedback and adjustment, reciprocal accountability, long-term commitment, flexibility, independence, complementarity, partnership, mutual benefit, relationship between equals, joint ownership, autonomy and shared control – barring dependency, are important to a South-South teaching collaboration. These principles, together with motivation, willingness to share ideas, mutual respect and a relationship of trust should be the building blocks for a cohesive collaboration.

Limitations are duly acknowledged. This study reports on two capacity development collaborations in Africa. This context may be different to other developing markets. Future research could be extended to other geographies. Furthermore, qualitative studies employing interviews and focus groups would shed further light on these principles.

This study contributes to the literature by offering capacity development through a different lens, with a focus on teaching capacity between partners in the South. It is through the educators, on the teaching side, that capacity development has the propensity to impact the human capital of the students through the delivery of a quality academic programme (Robson, 2017) and ultimately the sustainability of the education sector.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The author declares that she has no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Adriansen, H. K., & Madsen, L. M. (2019). Capacity-building projects in African higher education. *Learning and Teaching,* 12(2), 1-23. https://doi.org/10.3167/latiss.2019.120202

Altbach, P. G. (2004). Globalisation and the university: Myths and realities in an unequal world. *Tertiary Education and Management,* 10(1), 3-25. https://doi.org/10.1080/13583883.2004.9967114

Boshoff, N. (2010). South-South research collaboration of countries in the Southern African Development Community (SADC). *Scientometrics,* 84, 481-503. https://doi.org/10.1007/s11192-009-0120-0

Chaturvedi, S. (2016). The development compact: A theoretical construct for South–South cooperation. Research and Information System for Developing Countries, Discussion Paper No 203. https://doi.org/10.1177/0020881717705927

Eade, D. (1997). Capacity-building: An approach to people-centred development. Oxfam.

Enders, J. (2007). The academic profession. In Forest, J.J.F. & Altbach, P.G. (eds.), International Handbook of Higher Education (pp. 5–21). Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-4012-2_2

Färnman, R., Diwan, V., Zwarenstein, M., & Atkins, S. (2016). Successes and challenges of north-south partnerships - Key lessons from the African/Asian regional capacity development projects. *Global Health Action,* 9(1), 1-10. https://doi.org/10.3402/GHA.V9.30522

Ishengoma, J. (2016). Strengthening higher education space in Africa through north-south partnerships and links: Myths and realities from Tanzania public universities. *Comparative and International Educatio*n, 45(1), 1-17. https://doi.org/10.5206/cie-eci.v45i1.9282

Lopes, C., & Theisohn, T. (2003). Ownership, leadership and transformation: Can we do better for capacity development? Earthscan Publications Ltd.

Lusthaus, C., Adrien, M., & Perstinger, M. (1999). Capacity development: Definitions, issues and implications for planning, monitoring and evaluation. *Universalia Occasional Paper,* 35, 1-21. Universalia, Montreal.

Ofir, Z. (2021). Evaluation in transition: The promise and challenge of South-South cooperation. *Canadian Journal of Program Evaluation,* 36(2), 120-140. https://doi.org/10.3138/CJPE.71630

Owusu-Nimo, F., & Boshoff, N. (2017). Research collaboration in Ghana: Patterns, motives and roles. *Scientometrics*, 110, 1099-1121. https://doi.org/10.1007/s11192-016-2221-x

Pearson, J. (2011). Training and beyond: Seeking better practices for capacity development. OECD Development Co-Operation Working Papers, No. 1. OECD Publishing. https://doi.org/10.1787/22220518

Robson, S. (2017). Developing and supporting excellent HE teaching: Opportunities and challenges. In French, A & O'Leary, M. (eds.), Teaching Excellence in Higher Education: Challenges, Changes and the Teaching Excellence Framework (pp. 109–137). Emerald Publishing Limited, Bingley.

United Nations Development Programme (UNDP). (2009). Capacity development: A UNDP primer.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

https://www.undp.org/content/dam/aplaws/publication/en/publications/capacity-development/capacity-development-a-undp-primer/CDG_PrimerReport_final_web.pdf

United Nations Office for South-South Cooperation (UNOSSC). (2019). South-South and triangular cooperation in action: Pacific Islands development forum. https://drive.google.com/file/d/1UxV2203DElHuYmsBPRwvJJbvCscXSp9S/view

Vallejo, B., & Wehn, U. (2016). Capacity development evaluation: The challenge of the results agenda and measuring return on investment in the global south. *World Development,* 79, 1-13. https://doi.org/10.1016/j.worlddev.2015.10.044

Vincent-Lancrin, S. (2007). Developing capacity through cross-border tertiary education. In Vincent-Lancrin, S. (ed.), Cross-border Tertiary Education: A Way towards Capacity Development (pp. 47–108). The World Bank and OECD Publishing, Paris.

Wan, C. D., & Sirat, M. (2018). Internationalisation of the Malaysian higher education system through the prism of south-south cooperation. *International Journal of African Higher Education*, 4(2), 79-90. https://doi.org/10.6017/ijahe.v4i2.10298

Were, V., Jere, E., Lanyo, K., Mburu, G., Kiriinya, R., Waudo, A., Chiteba, B., Waters, K., Mehta, P., Oluoch, T., & Rodgers, M. (2019). Success of a South-South collaboration on Human Resources Information Systems (HRIS) in health: A case of Kenya and Zambia HRIS collaboration. *Human Resources for Health*, 17(6), 1-8. https://doi.org/10.1186/s12960-019-0342-z

Whitaker, B. E. (2004). US-South African research and training collaborations. Social Science Research Council, US.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Team projects to promote interest in basic microbiology

Linda Mezule

Water Systems and Biotechnology Institute, Riga Technical University, Latvia

Abstract

Traditional lecture-based approaches have long been the cornerstone of undergraduate education; however, the paradigm is shifting towards more interactive and engaging methodologies. Flipped-classroom, online tools, gamification are only some of the recommended approaches. Thus, recognizing the transformative impact of collaborative learning, this article explores the introduction of group work via team projects in undergraduate microbiology courses as an innovative pedagogical strategy. Furthermore, a new concept of allowing students to select the specific topic from a predefined field, ensures the need to perform literature research and brainstorming during the course. As part of the activity, the students need to set-up their individual experimental plan. No formal instructions are provided on what work must be done. The selected techniques are subsequently validated in laboratory experiments and presented as a research project. As a result, after the course "Basics in Microbiology" undergraduate students have obtained skills not only in preparation of a scientific work (as precursor for Bachelors thesis), but also in teamwork, own task set up, and collaboration just within 13 weeks of study.

Keywords: Group projects; collaborative learning; undergraduate microbiology

How to cite: Mezule,L. (2024) Team projects to promote interest in basic microbiology. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 908-913.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Modern research underscores the significance of active learning during science, technology, engineering, and mathematics (STEM) education, emphasizing the need to move beyond simple memorization, and encourage critical thinking and problem-solving skills (Thibaut et al., 2018). Group work, defined as collaborative activities where students work together to achieve shared learning goals, aligns seamlessly with these educational principles. Several studies have highlighted the benefits of incorporating collaborative learning strategies in science education (Luginbuhl and Hamilton, 2013; Trempy et al., 2002). One of these is Project-Based Learning (PBL) where the curriculum concepts are taught through a project fulfilled by the students (Bell 2010). Over the years PBL has been proposed as a practical learning approach in various STEM fields, like biology, mathematics (Burks, 2022; Jimenez-Gaona and Vivanco-Galvan, 2024), and key components include problem assignment, task definition, joint "brainstorming" and individual/joint problem solving (Wood, 2003). Usually these projects are guided by an inquiry question that drives the research and allows students to apply their individual knowledge. Moreover, collaborative approaches have been shown to enhance students' communication skills, teamwork abilities, and overall academic performance. At the same time, various factors, e.g., cognitive, social, language and previous knowledge, should be taken into account (Arvaja and Häkkinen, 2010), especially if groups are formed randomly. From student viewpoint, PBL are often associated with increased workload (Wood, 2003) and some resistance might occur. Within this paper a framework for group projects in microbiology is described. The approach facilitates collaborations, strengthening and application of the practical skills.

2. Course "Basics in Microbiology" structure

The course "Basics in Microbiology" (9 ECTS, undergraduate level, 3rd semester, study programme "Biotechnology and Bioengineering", provided by Riga Technical university), is the first study course covering microbiology in the study program and is organized as a 13-week module and covers theoretical lectures in practical microbiology (laboratory techniques, methods, cultivation and identification principles) and various fields linked with microbiology, e.g., water, soil, engineered systems. To obtain practical skills 3 defined laboratory works (cultivation, microscopy examination of bacteria, yeasts and moulds) are fulfilled. In addition, a student project is included in the assessment and comprise one third of the course grade.

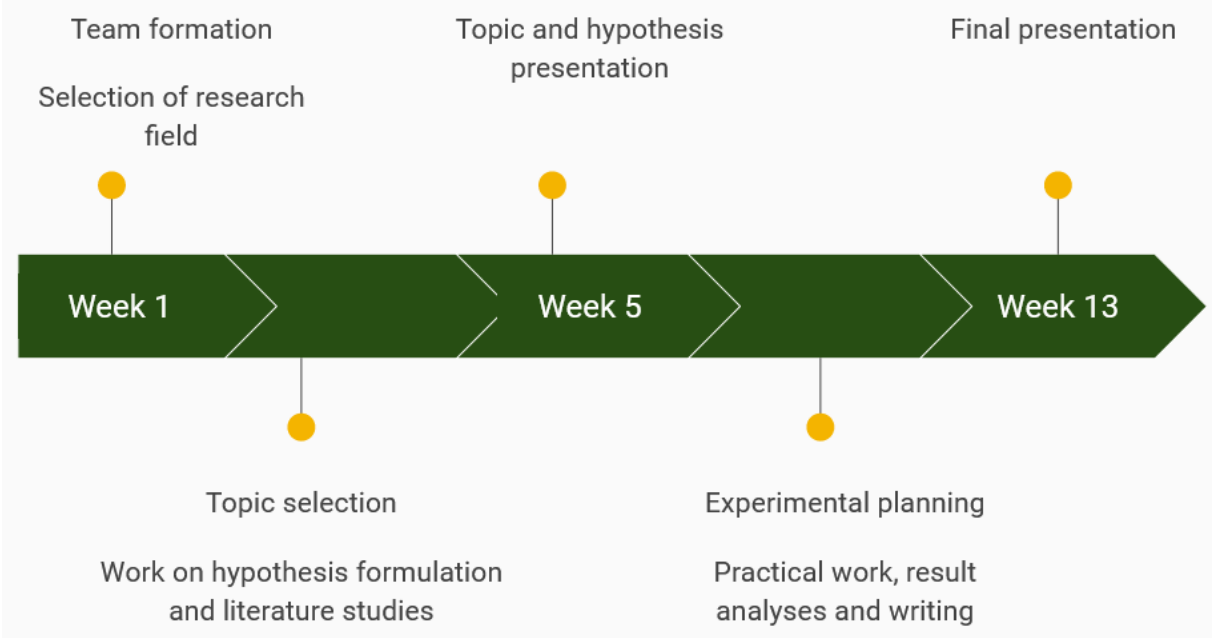
2.1 Course work activity description

During the first week of the course, the curriculum includes topic on History of Microbiology where traditional lecture is replaced by "public debates". During this activity students act as famous historical microbiologists, e.g., Francesco Redi, or their opponents (person/group of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

people that at the time in the past were representing an opposite view). The winner of the debate is estimated by other students and receives a bonus point. After the debates, random groups of 4-5 students are formed (usually by a raffle). Those groups that have the most bonus points from the debates are allowed to select the research field for the group projects first. Each research field can be selected only once. The provided research fields are broad and do not present any hints for research, e.g., water microbiology, food microbiology. Then the students independently work to develop project topic. Each week students have at least one consultation with the supervisor to discuss the topicality, research novelty and potential scientific soundness of the topic. At week 5 the students present their selected topics, literature review and research question as a 10 – 15 minute group presentation to an independent panel of at least 2 supervisors (Fig. 1). After the formal agreement of the topic, the students work to set up of the experimental plan. Due to the specifics of the course, basic microbiology techniques, e.g., cultivation, microscopy, flow cytometry, spectrometry, are allowed for the practical work. After the confirmation of the research plan, the students perform their practical experiments in the lab. Constant supervision is provided to guarantee the appropriateness of the work. On week 15 the students make a final group presentation in front of a panel of at least 4 faculty members and provide a written form of the work (~ 20 pages, IMRAD format). The evaluation is based on the quality of the presentation and submitted work.

Fig. 1 – Team projects timeline



Source: Own elaboration

2024, Editorial Universitat Politècnica de València BY-NC-SA

3. Results and discussion

Typically the most favoured research fields are those that are familiar or easily understandable to the students, e.g., water microbiology, food microbiology or soil microbiology. At the same time, these topics usually cause the biggest problems to select one single topic and formulate the research question. Occasionally, the student teams change their topic after week 5 presentation due to critical comments by other students or the faculty. This in turn results in negative feedback as excess workload during the course.

Unfortunately, most of the time the selection of the topic is not based on literature research but on the wish and interests of students – group leaders. They tend to promote their topic of interest. Subsequently, literature research is performed mostly to support the selection of the topic and not to search for the topic. Often the students even start with the experimental set-up and get confused when during consultations, literature based evidence and research question is requested prior practical work. Newertheless, within 5 – 8 weeks the students usually set their research topics. Sample titles of the projects are presented in Table 1 and demonstrate the broad spectrum of research that can be fulfilled on initially indentical fields of research.

Table 1 – Titles of group projects selected by the students based on the provided research fields

Research field	Title	Year
Water microbiology	Bacteria in reusable bottles	2021
	Ability of microorganisms to grow in natural mineral water	2022
	Impact of flow velocity on the retention of *Escherichia coli* in a sand sediment column	2023
Soil microbiology	Impact of chemical and biological fungicides/herbicides on soil microbial diversity and *Triticum aestivum* growth	2021
	The impact of light irradiation wavelength on microbial diversity in soil	2022
Food microbiology	Changes in nutrient levels of expired oat milk	2021
	Viability of lactic acid and bifidobacteria in dairy products under digestive system conditions	2022
	Depth of mould growth in apple jam with various sugar concentrations	2023
Biocides and antimicrobials	*Pseudomonas aeruginosa* biofilm disinfection with hydrogen peroxide	2021
	Stickiness of handrubs as a reason for increased microbial transfer	2023

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Indoor air quality	The impact of air flow on spread of *Penicillium* in indoor microclimate	2022
	Microclimate in car salons	2023
Personal protective equipment	Bacterial pollution levels at differently used face masks	2021
Biodegradation	Inactivation of pathogenic *Escherichia coli* by algal antibacterial metabolites	2022
Microbial resistance	Application method for propiconazole and influence of environmental factors on development of resistance in *Aspergillus niger*	2023

Source: Own elaboration

Despite the generally positive feedback from both students and faculty, some negative learning experiences from students have arisen. The main complaints have been related to identical grading for the whole group, especially when the group comprise more than one academically-at-risk student. At the same time, for the reduced performance students, the work in a group allows to obtain higher grading. Cooperative learning may not be suitable for all science content, but it certainly is of value when students are asked to use critical thinking, analysis, integration, and synthesis skills, in addition to communication and teamwork skills (Trempy et al., 2002). Furthermore, due to the changing groups and formulation of new ideas, the course provides the faculty with new scientific ideas and research concepts.

4. Conclusions

Within a 13-week period, the students obtain not only theoretical knowledge in basic microbiology concepts and laboratory work principles, but also use this knowledge to perform literature research, learn how to form research hypothesis, plan and conduct an experiment, and process and present the results. Furthermore, random formation of teams allows both honor and academically-at-risk students to obtain the necessary skills.

Acknowledgements

No funding has been received for the development of the research. The author thanks all students who have contributed to preparation of all course works.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

2024, Editorial Universitat Politècnica de València BY-NC-SA

References

Arvaja, M., & Häkkinen P. (2010) Social aspects of collaborative learning. In Peterson, P., Baker, E., McGaw, B. (Eds.) International Encyclopedia of Education (Third Edition), Elsevier, p. 685-690.

Bell, S. (2010) Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House*, 83, 39-43. https://www.jstor.org/stable/20697896

Burks, T.N. (2022) Improving student attitudes and academic performance in introductory biology using a project-based learning community. *Journal of Microbiology & Biology Education*, 23(1), 1-9. 10.1128/jmbe.00216-21

Jimenez-Gaona, Y., Vivanco-Galvan, O. (2024) Biotechnology project-based learning encourages learning and mathematics application. *Frontiers in Education*, 9:1364640. doi: 10.3389/feduc.2024.1364640

Luginbuhl, S.C., & Hamilton, P.T. (2013) Cooperative learning through team-based projects in the biotechnology industry. *Journal of Microbiology & Biology Education*, 14(2), 221-229. http://dx.doi.org/10.1128/jmbe.v14i2.608

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., Boeve-de Pauw,J., Dehaene, W., Deprez, J., De Cock, M., Hellinckx, L., Knipprath, H., Langie, G., Struyven, K., Van deVelde, D., Van Petegem, P. and Depaepe, F. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Jourrnal of STEM Education*, 3(1), 02. https://doi.org/10.20897/ejsteme/85525

Trempy, J.E., Skinner, M.M. and Siebold, W.A. (2002) Learning microbiology through cooperation: Designing cooperative learning activities that promote interdependence, interaction and accountability. *Microbiology Education*, 3(1), 26-36. doi: 10.1128/me.3.1.26-36.2002

Wood, D.F. (2003) Problem based learning. *BMJ*, 326(7384), 328-330. https://doi.org/10.1136/bmj.326.7384.328

BY-NC-SA 2024, Editorial Universitat Politècnica de València

An activity to promote entrepreneurship and sustainable tourism business models

Vicent Caballer-Tarazona[a] and María Caballer-Tarazona[b]

[a]Corporate Finance Department, Universitat de València, Spain
[b] Department of Applied Economics, Universitat de València, Spain

Abstract

Within the subject "Financial Management of Tourism Companies" in the fourth year of the Tourism degree program during the 2023/24 course (autum semester), students are required to propose an entrepreneurial project focused on sustainable tourism as part of their course assesment. Specifically, students must design a sustainable tourism business idea that encompasses financial considerations covered in the subject, such as cash flows that the business will generate and calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of the project.

Furthermore, students must document and detail all expenses the business will incur and specify revenue forecasts. A financing plan should also be included. Additionally, the business idea should incorporate a sustainability component, such as the installation of solar panels, sourcing zero-kilometer food, offering ecological travel discounts and so on..

The rubric used to assess the activity is structured as follows: 10% for NPV and IRR calculation, 30% for itemized incomes and expenditures, 30% for project feasibility, and 30% for the originality of the sustainable proposal.

The objective of this activity is to immerse students in a context of real entrepreneurship and encourage them to apply an holistic approach and consider sustainability as a key aspect of their business activity.

Keywords: classroom activity; entrepreneurship; sustainability; tourism project; working in groups.

How to cite: Caballer-Tarazona, V. and Caballer-Tarazona, M. (2024) An activity to promote entrepreneurship and sustainable tourism business models. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 914-918. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Due to the climate emergency, the fields of sustainability and entrepreneurship have garnered increasing attention across diverse industries, catalyzing transformative practices and innovative initiatives. Within the realm of tourism, a sector profoundly interconnected with environmental, social, and economic dimensions, the integration of sustainability principles and entrepreneurial endeavors holds immense significance. As the global tourism landscape evolves, universities play a pivotal role in shaping the future trajectory of the industry through comprehensive education, research, and knowledge dissemination (Hall & Williams, 2008).

This activity proposal endeavors to delve into the dynamic intersection of sustainability and entrepreneurship within university tourism studies in the University of Valencia. By examining the symbiotic relationship between these two domains, we aim to elucidate their collective impact on fostering responsible tourism practices, driving economic development, and nurturing environmental stewardship.

The urgency of addressing sustainability challenges in tourism cannot be overstated. As the industry grapples with issues ranging from overtourism and resource depletion to cultural commodification and climate change, the imperative for holistic and innovative solutions becomes increasingly evident (López Sánchez & Pulido Fernández, 2013). Overtourism, characterized by overcrowding at popular destinations, not only diminishes the quality of experiences for visitors but also poses significant environmental and social risks, including habitat destruction, pollution, and strains on local infrastructure and resources. Simultaneously, the unchecked exploitation of natural resources exacerbates environmental degradation, threatening the very landscapes and ecosystems that attract tourists in the first place (Dodds & Butler, 2019) .

Entrepreneurship, with its intrinsic capacity for creativity, risk-taking, and value creation, emerges as a potent catalyst for effecting transformative change within the tourism sector (Andrade, Baier, & Gaviria, 22). By harnessing entrepreneurial mindset and sustainable business models, tourism enterprises can not only mitigate adverse impacts but also catalyze positive socio-environmental outcomes.

Moreover, universities serve as fertile grounds for cultivating the next generation of tourism professionals, equipped with the knowledge, skills, and ethical framework necessary to navigate the complexities of a rapidly evolving industry (Ruhanen & Bowles, 2019). Through interdisciplinary curriculum, experiential learning opportunities, and industry partnerships, academic institutions play a pivotal role in instilling sustainability ethos and entrepreneurial spirit among students pursuing tourism studies. By integrating sustainability principles into pedagogical approaches and fostering entrepreneurial mindset, universities can empower

BY-NC-SA 2024, Editorial Universitat Politècnica de València

future leaders to drive innovation, promote social equity, and foster environmental resilience within the tourism sector.

With this activity we propose a way to promote innovation to create innovative ideas that allow us to combat climate change without neglecting the importance of entrepreneurship to train future professionals in the tourism sector.

2. Some additional guidelines

This activity is focused on students of the subject Financial management of tourism companies in the fourth year of the degree in Tourism. In the 23/24 academic year there were 31 students enrolled. It is an individual work with an approximate length of between 10 and 15 pages including tables, with 11 calibri font and single line spacing. The activity is planned in the middle of the course, after having introduced some financial concepts in class and the deadline to submit it is until the last day of the course, so you have about 7 or 8 weeks to complete the work.

The instructions given to the students are as follows:

1.Cover Page

2.Table of Contents

3.Introduction. In this section, the main characteristics of the business will be described. What type of tourism business it is, location, dimensions, project duration, prices, and other relevant aspects to present your investment project. In this part, the innovative features that make the business sustainable for the environment are also explained.

4.Estimation of Cash Flows. Insert tables with details of income and expenses and calculate cash flows. If you provide a link from where you obtained the prices of furniture, land, constructions, supplies, etc., you will receive a higher grade.

5.Calculation of Net present value (NPV), Internal rate of return (IRR), and break-even point based on the cash flows calculated in the previous section.

6.Project Financing. We will assume that the project will be financed (totally or partially) with a loan. Include the characteristics of the loan and an amortization table.

The evaluation rubric will be carried out as follows: Originality and creativity of the sustainable business idea (30% of the final grade), feasibility of the business (30%), detail in the calculation of income and expenses (30%), presentation and format (10%)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Results

This activity was quite motivating for the students because it allowed them to develop their creativity and be managers of their own business in an imitated way. However, many of the works were focused on conventional tourism ideas seted on saturated destinations. For future courses, it would be convenient to provide more examples of sustainable businesses so that students have more references to carry out their projects. We firmly belief that it is important to provide students with alternative references to the mean stream trend in order to open up their spectrum to the diversity. The main challenges that the students faced were the process to obtain information about both the price of real estate and supplies and the location of the tourism business.

The students proposed sustainable ideas such as cabins made of recycled material, hotels with Zero-Km food, self-sufficient rural lodging with energy from solar panels and wells, sustainable agrotourism businesses, discounts for travelers on ecological means of transport among others. .

The feedback received was very positive and the activity was well received, since it allowed the concepts taught in the subject to be applied and a first approach to sustainable entrepreneurship to be established.12.9% of the works were rated as excellent. In light of the quality of some of the proposals submitted, for the next academic year, the best work will be proposed to apply to the MOTIVEM programme at the University of Valencia. MOTIVEM is a program aimed at recognising the best entrepreneurial projects and business ideas in any area of knowledge and which involve a specialisation in triple impact, creating value for the territory and for people from the triple dimension of sustainable development: economic, social and environmental. We believe that this incentive can improve students involvement in the subject.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

References

Andrade, N., Baier, H., & Gaviria, M. (22). An Overview of Sustainable Entrepreneurship in Tourism, Destination, and Hospitality Research Based on the Web of Science. Sustainability, 14(22).

Dodds, R., & Butler, R. (2019). Overtourism.Issues, realities and solutions. De Gruyter: Berlín.

Hall, C. M., & Williams, A. M. (2008). Hall, C. M., & Williams, A. M. (2008). Tourism and innovation. Routledge. Routledge.

López Sánchez, Y., & Pulido Fernández, J. (2013). Incorporating sustainability into tourism policy: A strategic agenda for Spain. European Journal of Tourrism research, (7) 57-78.

Ruhanen, L., & Bowles, L. (2019). Student Perspectives of Responsible Tourism Behaviour: The Role of Tourism Education. Journal of Hospitality & Tourism Education , 255-265 .

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Pedal for future

Nuria Arenas Peiró, Susana Martí Sendra[a]

[a]Automotive Department , IES Maria Ibars, Dénia.

Abstract

Our planet suffers and faces new economic, social and environmental challenges, so we need to adopt a new approach and raise awareness in society, especially among young people, of global environmental problems. The excess of combustion vehicles in cities is the cause of air pollution problems and worsens the quality of life of citizens with different health problems, so it is one of the environmental problems that must be taken into account for our future. It is not necessary to be a big city to begin to notice these effects, we believe that in our hand is to take measures to reverse, as far as possible, its impact on our immediate environment and in our case the city of Denia. Sustainable development consists of making economic growth, social cohesion and environmental protection compatible, thus ensuring a better quality of life for the current and future population, without increasing the use of natural resources beyond the capacity of nature to provide them indefinitely.

With this project we have changed methodologies and have managed to raise awareness of the ODS among our students. We have obtained information to collaborate in the mobility plan of the city of Denia and we are making a bike library in our school so that all students have a bike .

Keywords: bicycle; sustainable mobility; ODS; city project; environmental problems.

How to cite: Arenas Peiró, N. and Martí Sendra, S. (2024) Pedal for future. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 919-926. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Facilitating and managing mobility in cities and metropolitan areas is a complicated challenge, it is difficult, especially in urban areas where moving is complicated.

We are aware that our planet is suffering and facing new economic, social and environmental challenges, so we need to adopt a new approach and raise awareness in society, especially among young people, of global environmental problems. In the Valencian Community, air pollution has been increasing in recent years, especially in large cities. The most common and harmful air pollutant gases are carbon monoxide, sulfur dioxide, chlorofluorocarbons and nitrogen oxides produced by industry, as well as gases produced in the combustion of vehicles. This involves significant damage, nuisance and risks for people and living beings that coexist in nature. Transport accounts for a quarter of greenhouse gas emissions, which continue to increase. The European Commission's Green Pact aims to reduce these emissions by 90% by 2050 (EU Green Deal 2020).

It is for all these reasons that in recent years, countries have been participated and discuss their environmental policies in different conferences and international summits on the environment and sustainable development.

Active mobility to schools has been associated with both psychological and physical benefits for children and adolescents. Despite this, the number of schoolchildren who make this journey on foot or by bicycle has been considerably reduced. Thus, it is considered that promoting active means of transport among different students will be based on three key aspects:

1) Promotion of healthy habits.

2) Sustainable and safe mobility.

3) Increasing the autonomy and awareness of schoolchildren in their movements around the cities to prevent accidents.

In this way, the aim is to promote health through the promotion of physical activity in daily activities, while increasing the skills of schoolchildren to prevent traffic accidents and related injuries.

2. Justification

The IES Maria Ibars is an educational center that offers Secondary education, Baccalaureate, as well as vocational education training such as electromechanics of vehicles. These Vocational educational training studies have very present in their curriculum the pollution produced by vehicles; in fact, there are specific regulations for it.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Our IES is in Denia, which has about 42,000 inhabitants in a coastal area with a Mediterranean climate and that has the ideal conditions for the population to go by bicycle. This currently does not happen and that is what we want to investigate. We would also like to mention that a project of this kind has never been carried out in our center and the teaching team, although they were lacked of experience, they showed lot of interest and it was a motivating challenge.

Among the objectives of the project we highlight:

- Analyze the causes of the low use of bicycles by the students of the center as a means of transport to move around Denia.

- Interpret the results of the causes and propose possible solutions to improve the use of healthier and more environmentally sustainable transport.

- Raise awareness of the students of the center and transversally to their families of the problem of pollution and the importance of exercise as a healthy habit.

- To promote the values of solidarity and teamwork. With a final objective to make visible the problem of pollution in the cities and to promote a healthier encourage, a healthier life for the entire school-age population.

3. Project methodology and development

The project has been carried out by vocational education training students of the 1st of medium grade of vehicle electromechanics in collaboration with the 1st year students of intermediate administrative and 2nd year of administrative basic vocational training, thus making it become an interdisciplinary project and horitzontal character of our center.

The total number of students involved was 480 participants, which represents 54% of the total number of students in the school.

3.1 Production of signage

To begin with, the students developed a dissemination plan, designing posters to announce the students of the center and the rest of the educational community (families and teachers) the participation in this Endesa Foundation project. These posters informed about the objectives of the project and the need to have bicycles available for recycling and bicycles to be recycled and later donated to a center for children without resources and other associations belonging to the city of Denia.

This activity allowed all the students to participate in each of the phases of the plan. The great multiculturalism of the students of the center made that the design of the posters was in different languages: Spanish, Valencian, English, and Arabic.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 1 - Model of diffusion poster (a)



Source.Authors

3.2 Survey development

In terms of the techniques and instruments proposed, a survey was prepared for the rest of the students of the center, which was used to collect different information on healthy habits related to the project. The survey consisted of 19 questions that were made up by the participating students themselves, who proposed different questions

The survey was conducted in Spanish, Valencian and English and students were who organized themselves to reach the many respondents as possible. The students worked on soft skills like oral communicative competence and oral presentation techniques. Thus, the students collected data from 480 surveys.

3.3 Dissemination and awareness

Awareness-raising work was carried out as a further strategy to publicize current environmental problems, as well as recommendations for a healthy diet and the importance of exercising. QR codes were generated in order to raise awareness, be aware of new technologies and make the information that reached the students more attractive.

Likewise, the local police of Denia participated in the event and gave several talks to the students about the new road regulations in Denia for the new types of personal transport, including bicycles, to facilitate coexistence between different kind of vehicles.

In addition, to encourage the use of reading and to ensure that the dissemination was posters with QR codes were hung and then a raffle was held (gifts provided by local companies).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3.4 Bicycle recycling

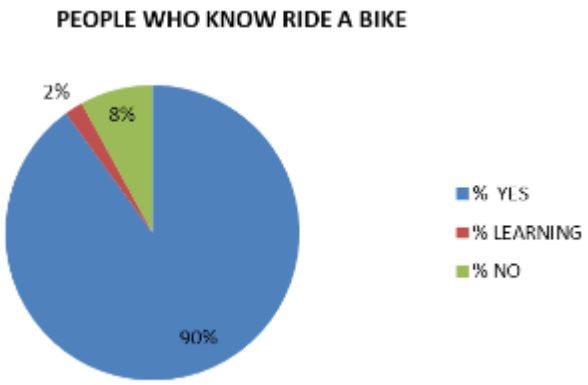
In total, 12 of the donated bicicles were recycled and the rest were used for spare parts. The students designed an efficient system for working in the workshop.

All this has been done with a democratic, participatory, horizontal, collaborative, and peer-to-peer learning methodology. It was "the students" who decided the project title, the specific theme, as well as the questions of the questionnaire and the center where they would finally donate the bicycles in Denia.

4. Results

From the data analyzed, 66% of those surveyed live in Denia, and only 11% live more than 15 km from the educational center. So that 89% would find it easy to get to the center by bicycle. 58% of the students surveyed own a bicycle, highlighting, the fact that 34% (most of them are minors) of this percentage are male and female minors. That is 42% do not have bicycles, either for transportation to school or for recreational use. Most people know how to ride a bike, only 10% don't know about it and about 2% of them are learning to do it.

Fig. 3 – Survey results about people who know ride a bike

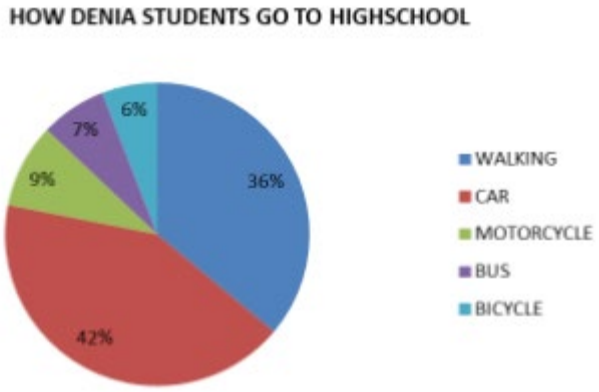


Source. Authors' analysis

One of the most significant questions of the project and one that has made us think about it is to know the type of transport they use to go to school every day. Thus, it has been observed that the bicycle is one of the least used means of transport and that the most used means of transport is still the car. The option of sharing a car only accounts for 8% of the total. From analysis of these results, we are aware that the culture of transport must change in order to achieve sustainable mobility in the city.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 4 – Survey results about how students go to school

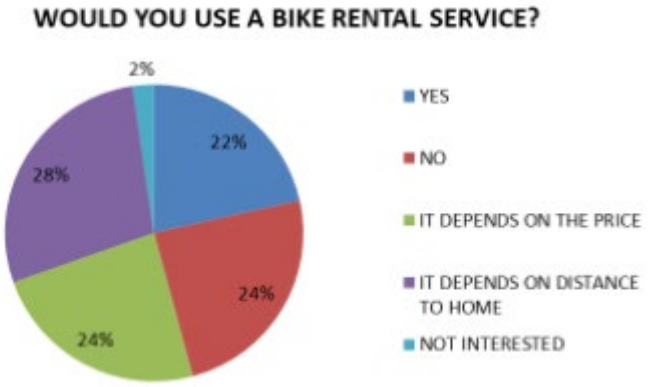


Source. Authors' analysis

Among the reasons given by students for not using bicycles, it is observed that more than half do not come because they are more than 5 km away, while 30% do not come because of the the lack of safety due to the deficiency of a real and functional bike lane in the municipality, often cities have stretches of bike lanes but they do not really connect the whole city.

One of the purposes of the project is to promote the use of bike to come to the highschhol, for this reason in the same way we have a borrow book service, we'd have a borrow bike service.

Fig. 5 – Survey results about use of a bike rental service



Source. Authors' analysis

2024, Editorial Universitat Politècnica de València BY-NC-SA

5. Conclusions

The conclusions drawn from this project have been divided into two parts:

On the one hand, the impact of participation on students and teachers in this type of project:

- The learning in this project has been experiential and of a competency-based nature. Teachers have to change our role and design learning activities where the students themselves are participants in their own learning.

- The learning objectives were shared with the students.

- The work was based on PBL methodologies "Problem based learning - problem based learning" and APS "Learning and service" methodologies, which detect and improve society's problems.

- The work on digital competence has been designed according to the European framework of digital competences (DIGCOMP), where the digital competence plays a fundamental with other competences such as communicative and linguistic competences.

On the other hand, the conclusions specifically related to the results obtained in the project are as follows:

-Only half of the students have bicycles even though they live in an area with such a privileged climate as Denia.

- The vast majority of students who do not go to school by bicycle is due to the lack of bicycle lanes that really connect the whole urban area and make them feel safer.

- There is a shortage of infrastructure in the center to park bicycles and this lack may also be due to the fact that there is no demand for bike parking.

As the project progressed this year and with the results of the previous year, we realized that many students do not have a bicycle, that once past the age of 12 or 13 years do not make the switch to a larger bike so they came up with the idea of building a "Bicycle Library" in the center. Just as they lend us a book at school, why not lend us a bicycle? The idea is to continue recycling bicycles that people donate to the center and manage a bicycle library that we are starting to build and will begin to operate at the end of the course. The idea is to have 20/25 bicycles available for loan, where the automotive students will provide the maintenance service in their tutoring hours on a continuous basis and now in the project, they are fine-tuning each one of them. The administrative students have prepared some forms for the management of the loan. It will be a free service.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Acknowledgements

No funding has been received for the development of the research

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper

References

Agroambient. (2015). La contaminación atmosférica. Recuperado el 16 de marzo de 2020 http://www.agroambient.gva.es/es/web/calidad-ambiental/la-contaminacion-atmosferica

Real decreto 161/2003 - Núm. 4.588. Diario oficial Generalitat valenciana, 5 de septiembre 2003.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Changing individuals, institutions and environmental conditions: an innovative hybrid participatory approach for sustainability in education

Ana Prades[a], Yolanda Lechón[a], Silvia Germán[a], Terhi Nokkala[b], Hannu Heikkinen[b], Anna Lehtonen[b], Niina Mykrä[b], Jose Antonio Becerra[c], Israel Marqués[c], Ricardo Chacartegui[c], Josep Espluga[d], Markku Lehtonen[d] and Ana Rosa Gamarra[a]

[a]CIEMAT, Spain
[b]University of Jyväskylä, Finland
[c]University of Seville , Spain
[d]Autonomous University of Barcelona, Spain

Abstract

This paper presents preliminary findings from the EU-funded ECF4CLIM project. It first introduces the initial definition of our European Competence Framework for a Low Carbon Economy and Sustainability Through Education. Then we present a number of practical interventions to promote sustainability competences that have been co-designed in 13 schools and universities from four EU countries. An innovative hybrid participatory approach that supports the co-design process is also presented. A total of 114 interventions have been codesigned in our SCTs & SCCs to empower and promote sustainability at our demonstration sites. The expected impacts of the interventions include changes in the environmental performance in our schools and universities as well as improvement of the individual and collective competences in the educational community. Many of the proposed interventions are energy-related. Specific recommendations will be proposed on how to promote education for energy sustainability through participatory approaches.

Keywords: sustainability competences; participatory approaches; crowdsourcing; European Competence Framework.

How to cite: Prades, A; Lechón, Y.; Germán, S.; Nokkala, T.; Heikkinen, H.; Lehtonen, A.; Mykrä, N.; Becerra, J.A.; Marqués, I.; Chacartegui , R.; Espluga, J.; Lehtonen, M. and Gamarra, A.R. (2024) Changing individuals, institutions and environmental conditions: an innovative hybrid participatory approach for sustainability in education. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 927-935.
https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The ECF4CLIM project (A European Competence Framework for a Low Carbon Economy and Sustainability Through Education www.ecf4clim.net) is funded by the European Commission under the GreenDeal call. It started on 1 October 2021 and will end on 30 September 2025.

Through a transdisciplinary and participatory process, ECF4CLIM develops, tests and validates a European Competence Framework (ECF) for transformational change, which will empower the educational community to act against climate change and towards sustainable development. Applying a novel hybrid participatory approach, rooted in participatory action research and citizen science, ECF4CLIM co-designs the ECF at 13 selected primary and secondary schools and universities from four EU countries (our Demonstration Sites, DSs), by: 1) elaborating a roadmap towards the improvement of sustainability competences, based on the EU JRC designed GreenComp framework (Bianchi et al. 2022), supported by crowdsourcing of ideas and analysis of existing ECFs; 2) establishing the baseline of individual and collective competences, as well as the baseline of environmental performance measured by selected indicators; 3) implementing practical, replicable and context-adapted interventions that foster the acquisition of competences; 4) evaluating the ability of the interventions to strengthen sustainability competences and environmental performance; and 5) validating the ECF.

Until now, the project has successfully designed the initial roadmap, completed the baseline assessment of individual and collective competences and environmental performance, and identified a preliminary set of interventions to be implemented at our selected schools and universities. Through our novel hybrid participatory approach, we also provided our educational communities with innovative organisational models of engagement and action for sustainability: Sustainability Competence Teams (SCTs) and Sustainability Competence Committees (SCCs). To further encourage learning by doing, a digital platform for crowdsourcing, IoT (Internet of Things) solutions for real-time monitoring of selected aspects of environmental performance, and a digital learning space were also co-designed with key actors of the educational community.

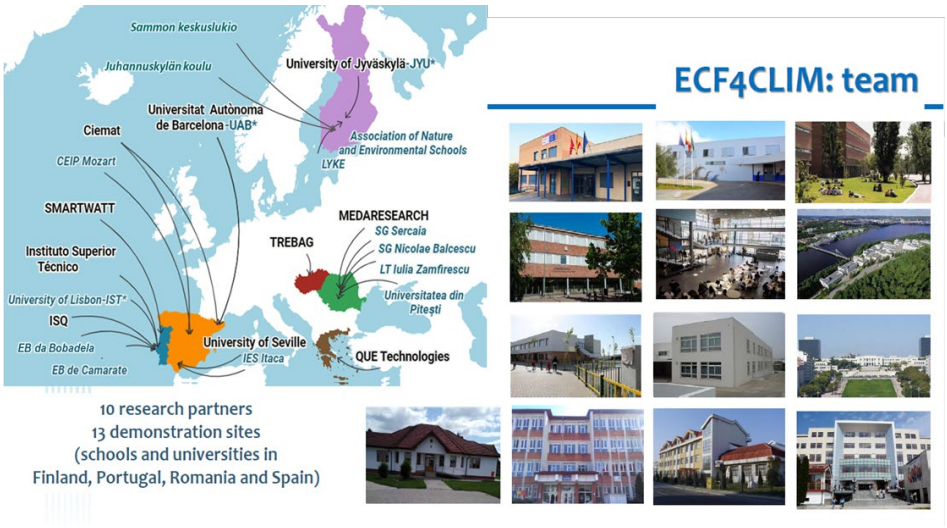
2. The innovative hybrid participatory approach

To foster participatory experiential learning, involving thinking in-action, doing and reflecting, the ECF4CLIM hybrid approach includes and combines elements from participatory action research, practitioner research, citizen science (Vohland et al., 2021), citizen engagement (Horlick-Jones & Prades, 2015; Rask et al. 2018), deliberative will formation (Englund 2016), crowdsourcing (Säily et al. 2020), and theory-based stakeholder evaluation (Rogers 2007; Hansen and Vedung 2010). In a participatory ethos, we engage students, teachers, parents and the wider educational community in contributing to climate

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

action and fostering transformational change towards sustainable development. This approach is vital for overcoming the various types of resistance to individual behavioural change and collective changes in social practices.

Figure 1– The ECF4CLIM team



Source: Own elaboration

2.1 Crowdsourcing

The elaboration of our initial roadmap comprised the use of a participatory will formation through a broad international crowdsourcing exercise. This crowdsourcing process invited and engaged a large and, diverse international group of stakeholders in education to discuss the factors that can enable or constrain efforts to promote sustainability in education as well as the means of operationalising the individual and collective competences outlined in the GreenComp. The crowdsourcing was implemented in two stages. First, a set of "dream and nightmare school" -workshops were organised to stimulate discussions on the participants' experiences on the enablers and constraints of sustainability education. Second, online discussions for international audiences were facilitated on the eDelphi platform to obtain a deeper understanding of the issues addressed in the crowdsourcing workshops. Altogether 579 educational stakeholders from a range of countries participated actively in crowdsourcing workshops and online discussions on the eDelphi platform. The roadmap was contructed based on the findings derived from both inductive and deductive qualitative analysis of the crowdsourcing data, as well as on an analysis of international and national policy documents and curricula. The ideas put forth by the crowdsourcing participants on the tools and essential next steps for developing sustainability in education were integrated into the roadmap.

Despite the variation of cultural institutional, demographic, and political contexts across the countries the following issues were regarded generally as essential for the promotion of

BY-NC-SA 2024, Editorial Universitat Politècnica de València

sustainability in education: awareness-raising, sufficient human and material resources, interacting with society and the local community, adequate infrastructure, effective management including visions and concrete strategies, cross-curricular and interdisciplinary education, and meaningful learning that combines theory with practice.Furthermore, the findings indicate that environmental performance and the individual and collective competences are essential factors conditioning the efforts to promote sustainability in various educational contexts.

2.2 SCTs / SCCs

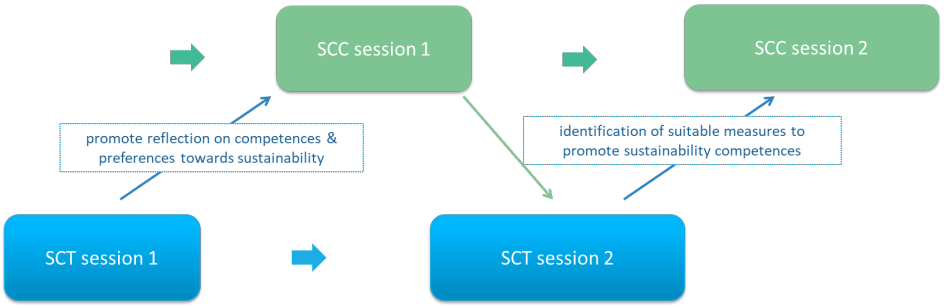
The ECF4CLIM hybrid participatory approach, partially based on STAVE tool – a tool that includes elements of both research and engagement (Horlick-Jones and Prades, 2015; Espluga et al, 2017) – allows the educational community to jointly identify, understand, assess and evaluate their own sustainability-related competences and obstacles to improvement. The communities engage in joint deliberation on how to encourage individual and collective behaviours that foster sustainability, and to jointly evaluate the outcomes of the learning experience. Two types of innovative organisational models of engagement and action for sustainability, sustainability competence teams and committees, were set up at each of the ECF4CLIM schools and universities that served as our demonstration sites. Each of them meets periodically, up to six times during the project. Key outputs from deliberations and reflections are shared and discussed at the subsequent group meeting.

- **Sustainability Competence Teams (SCT):** three teams, one with students, another with teachers, and a third with the organisational staff, to promote deliberation and reflection on the challenges, competences, and "intervention theories" (expected and observed causal relations between the interventions, environmental performance, and competences) associated with sustainable development.
- **Sustainability Competence Committees (SCCs):** one SCC, gathering representatives from the SCTs and from the wider educational community, such as public authorities and NGOs. Dialogue and deliberation are facilitated among all actors with the ultimate aim of fostering transformational change towards sustainability.

So far around 325 representatives from our 13 demonstration sites have participated in our SCTs and SCCs. The 1st and 2nd SCT/SCC meetings have already taken place. Their objectives were to promote an initial reflection on sustainability competences and preferences towards sustainability at schools and universities, and to identify suitable interventions to promote sustainability.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Figure 2 – Sustainability Competence Teams and Committees 1 & 2.



Source: ECF4CLIM D4.4 (2023)

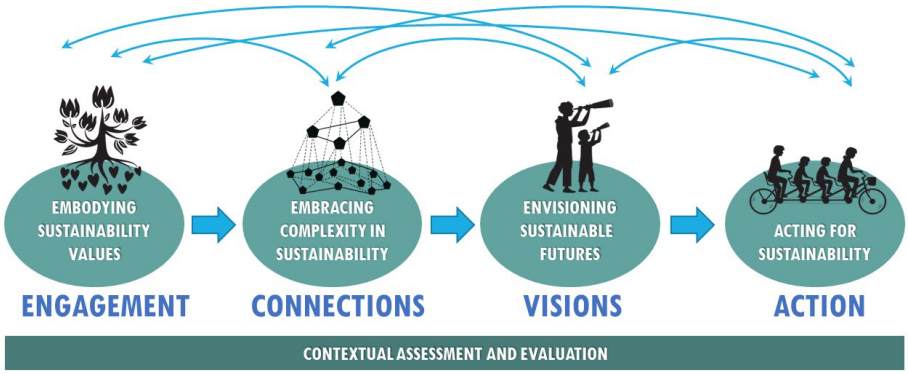
3. Preliminary results & findings

3.1. Initial roadmap

The initial ECF aimed to serve as a practical document that describes the essential individual and collective competences and provides tools for various stakeholders to map and foster the enablers of and overcome the constraints to sustainability in various educational contexts. It draws from the results of the crowdsourcing exercise, document analysis, and literature review. Structured as a roadmap, the initial ECF was based on the sustainability competences outlined in GreenComp. It has already been used at the demonstration sites and will be further elaborated and validated during the last phases of ECF4CLIM project.

The roadmap outlines four steps, each containing a description of the essential aspects, reflective questions, enablers, and tools for overcoming the constraints to promote sustainability in education.

Figure 3 – The ECF4CLIM initial roadmap



Source: Own elaboration

The first step, "engagement" aims to engage people in promoting sustainability by strengthening their understanding of sustainability and by fostering a collective will formation process that considers different stakeholders' needs, values, and perspectives. The

BY-NC-SA 2024, Editorial Universitat Politècnica de València

second step, "connections" aims at deepening people's understanding of the connections and the complexity associated with sustainability. The third step, "visions" focuses on envisioning alternative futures, mapping possible paths towards sustainability, promoting adaptability according to changing needs, as well as explorative relational thinking. The fourth step, "action" aims to create a strategic action plan that is based on the previous steps and identifies the available resources.

3.2 Interventions

A total of 114 interventions were co-designed to empower actors and promote sustainability at our demonstration sites. In the designing process of interventions, 87 were selected for implementation during the life of the project, while the remaining 27 were preliminary discarded due challenges for their implementation within the execution period. Some of the interventions that were initially discarded were nevertheless later reintroduced and are now being implemented.

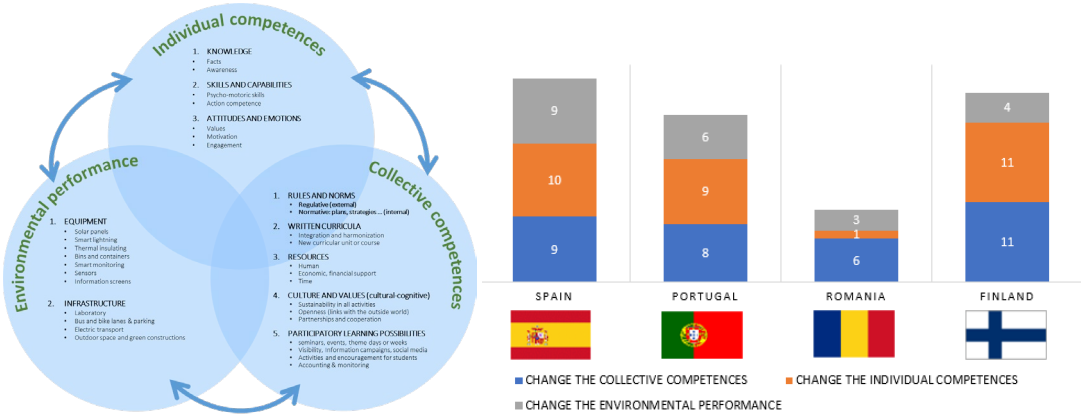
Relying on the ECF4CLIM **conception of sustainability competences,** the interventions were categorised according to their expected impact as follows:

- **Interventions designed to improve the environmental performance:** installing new equipment, upgrading infrastructures, and monitoring environmental performance.
- **Interventions designed to strengthen the individual competences**: promoting critical thinking among students and improving their knowledge through the dissemination of information, keeping of "awareness diaries", and participation in events and activities like field trips and competitions.
- **Interventions designed to strengthen the collective competences:** integrating sustainability-related elements in regulations and curricula, creating sustainability programs at master and doctoral level, digitalisation, and software development. Ultimately, these measures are expected to help turn the norms and principles of sustainability into taken-for-granted quasi-automatic collective behavioural patterns within the organisation in question.

Given the interrelationship between collective and individual sustainability competences, most of the proposed actions that target environmental performance or individual competences also serve to enhance collective competences.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Figure 4 – Co-designed measures classification.



Source: ECF4CLIM

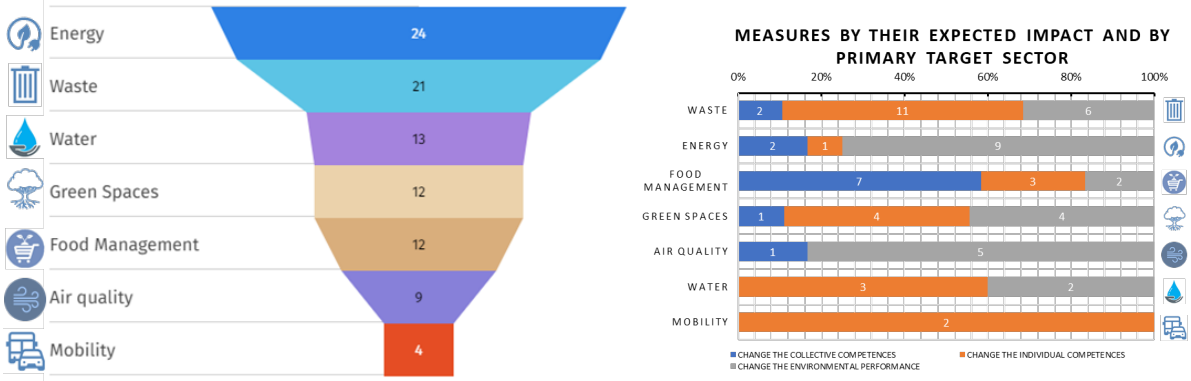
The interventions were also classified according to the **environmental area** in which the change is expected to take place. As can be seen from the graphs below, the **energy sector** is the area with the largest number of proposed interventions, including:

- Measures to reduce and monitor the buildings' energy consumption, mainly through the installation of LED lighting, accompanied by intelligent lighting systems. Through these actions, large energy savings are expected. Measuring devices will also be installed to analyse the evolution of electricity consumption in lighting. This information will be used as dissemination and teaching material.
- Measures to promote renewable energy production, mainly through the installation of photovoltaic or thermal solar panels, to reduce dependence on traditional fuels. These measures are expected to reduce CO_2 emissions and energy costs in the long term
- Measures to improve the comfort of educational spaces: double glazing and thermal blinds, improved insulation, or the implementation of adiabatic air conditioning systems as an alternative to conventional air conditioning systems
- Training sessions and programs to include topics such as energy consumption, carbon footprint and energy saving and efficiency in the curricula
- Measures to rise collective awareness of the need maintain and imrpove energy-related interventions over time.

At this early stage of the participatory process, **energy-related interventions are primarily expected to improve the environmental performance** of the schools and universities. Nevertheless, these energy related interventions will have an impact on the individual competences (awareness, knowledge, skills) and on the collective competences (institutionalising the interventions). In fact, 17 of the 24 energy-related interventions are focused on improving environmental performance, 6 are focused on working on collective competences, and 1 aims to develop individual competences

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 5 – Co-designed measures by environmental area, by expected impact and target sector.



Source: ECF4CLIM (D5.1)

4. Conclusions

The ECF4CLIm project is on-going and at this stage we do not have yet solid empirical evidence on the impact of the interventions on sustainability competences at our DSs. Key issues to explore in the forthcoming SCTs/SCCs include: Will the interventions operate as expected, through the foreseen mechanisms and produce the hoped-for outcomes? What kind of competences have proven crucial for the success of the interventions? How, if at all, the experience from the intervention has changed the initial assumptions held by the people involved concerning the preconditions of success of the interventions? Have those interventions that primarily aimed at improving environmental performance or individual competences also had impacts on the collective competences?

Connections between the different dimensions of sustainability deserve to be highlighted. Many interventions seek to foster energy savings by improving the existing infrastructures, but they can also promote desired behavioural changes, as the individuals involved obtain information of their own consumption patterns, and learn about their implications for sustainability. Moreover, the processes of planning, implementing, and evaluating infrastructure-improvement measures can help consolidate lasting collective practices and embed norms of collective behaviour that favour sustainability.

Once we have evaluated the impact of these energy-related interventions on the sustainability competences at our DSs, concrete recommendations will be proposed on how to strengthen education for sustainability in the energy sector through participatory approaches. The portfolio of energy-related interventions will also be mobilised when advancing through the successive steps in our Roadmap.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101036505.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper

References

European Commission, Joint Research Centre, (2022). *GreenComp, the European sustainability competence framework*, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/13286

Englund, T. (2016). On moral education through deliberative communication. Journal of curriculum studies, 48(1), 58-76.

Espluga, J.; Konrad, W.; Mays, C.; Oltra, C.; Poumadère, M.; Prades, A. (2016) "How to address citizens' practices and policies on sustainability? A consultative tool for brokering policy-related knowledge between the worlds of policymaking and everyday citizens' life" Evidence & Policy, 12 (3):381-404

Hansen, M.B. & Vedung, E. (2010). Theory-Based Stakeholder Evaluation. American Journal of Evaluation 31 (3), 295-313

Horlick-Jones, T., & Prades, A. (2015). Translating between social worlds of policy and everyday life: The development of a group-based method to support policymaking by exploring behavioural aspects of sustainable consumption. Public Understanding of Science, 24(7), 811-826.

Rask, M., Mačiukaitė-Žvinienė, S., Tauginienė, L., Dikčius, V., Matschoss, K., Aarrevaara, T., & d'Andrea, L. (2018). Public participation, science and society: Tools for dynamic and responsible governance of research and innovation (p. 152). Taylor & Francis.

Rogers, P. (2007). Theory-based evaluations: Reflections ten years on. New Directions for Evaluation, 114, 63–67.

Chacartegui Ramírez, R., J.A Becerra Villanueva, A.J Serrano Jiménez, I. Marqués Valderrama, N. Mykrä, C. Lago, S.German, M. Almeida, J. Espluga, M. Constantin. (2023) ECF4CLIM D5.1 Definition of interventions and actions to be implemented. https://www.ecf4clim.net/_files/ugd/1088b3_e3a0603b931945bfbc32cf4092d1c8ac.pdf

Säily, L., Huttunen, R., Heikkinen, H. L., Kiilakoski, T., & Kujala, T. (2020). Designing education democratically through deliberative crowdsourcing: the case of the Finnish curriculum for basic education. Journal of Curriculum Studies, 1-16.

Vohland, K. et al. (2021). Editorial: The Science of Citizen Science Evolves. In: Vohland, K., et al. The Science of Citizen Science. Springer, Cham. https://doi.org/10.1007/978-3-030-58278-4_1

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Designing a Massive Open Online Courses (MOOC) for Effective Learning in Electrical Energy Economics and Planning for Engineering Students

Nofri Yenita Dahlan[ab] and Jefri Dahlan[c]

[a]Solar Research Institute (SRI), Universiti Teknologi MARA, Malaysia
[b]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Malaysia.
[c]Institute of Continuing Education & Professional Studies (iCEPS), Universiti Teknologi MARA, Malaysia.

Abstract

This paper outlines the creation of a Massive Open Online Course (MOOC) tailored for Electrical Energy Economics and Planning course, intended for final-year students enrolled in the Bachelor of Electrical Engineering Programme at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM) in Shah Alam, Malaysia. The course aims to equip students with the ability to: 1) analyze the economic facets of the electrical energy market and transmission network, 2) choose suitable ancillary services to uphold system security, and 3) recognize transmission pricing methods for investing in transmission expansion. Developed in accordance with the Guidelines for Development and Delivery of Malaysia MOOC by the Ministry of Higher Education, the UiTM MOOC comprises three main components: a homepage/landing page, a content page, and a completion section. The course design integrates Gagne's Nine Events of Instruction to enhance the learning experience. The content spans seven topics, exploring the economic dimensions of components within the electricity supply industry. Diverse learning activities, including videos, animations, quizzes, tutorials, and online question-and-answer sessions, have been crafted to enrich the learning experience. The development of this MOOC offers an interactive learning platform for engineering students, facilitating their understanding of global and Malaysian electricity market models, thereby contributing to sustainable energy education.

Keywords: MOOC; online learning; energy economics; higher education.

How to cite: Yenita Dahlan, N. and Dahlan, J. (2024) Designing a Massive Open Online Courses (MOOC) for Effective Learning in Electrical Energy Economics and Planning for Engineering Students. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 936-944. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Massive Open Online Courses (MOOC) are digital learning platforms providing free and open access to a diverse array of courses. Designed to cater to a large audience, MOOC are characterized by their massive scale, allowing widespread participation. The primary objective of MOOC is to democratize education, offering individuals with internet access the chance to enroll and access top-tier educational content at no cost.

In line with the launch of the Malaysia Education Malaysian Education Blueprint 2015 -2025 (Higher Education) (MOE, 2015), Malaysian Higher Education Providers are encouraged to elevate Shift No.9: Globalised Online Learning (MOE, 2015). The objective is to broaden educational access, foster lifelong learning, enhance the quality of teaching and learning, reduce delivery costs, and position Malaysian Higher Education Providers prominently on the international stage. Corresponding to this progress, the Malaysia Ministry of Higher Education introduced four MOOC courses in early 2014 across four public universities in Malaysia including Universiti Teknologi MARA (UiTM). Using Open Learning as the MOOC platform, Malaysian MOOCs offer 884 courses through 20 local universities (JPT, 2024).

As part of the initiative to advance sustainable energy education at UiTM through MOOCs, the School of Electrical Engineering has involved in creating online courses for various energy-related courses, including Electrical Energy Economics and Planning. Engineering students often face challenges when dealing with economic theories due to their limited background in economics. Understanding economic theories and their applications to energy markets can be particularly daunting for individuals more accustomed to addressing technical problems. The developement of MOOCs with interactive features is anticipated to assist engineering students in overcoming these challenges, which is the focus of this paper.

2. Massive Open Online Courses (MOOC)

2.1 MOOC in UiTM

In UiTM, MOOC was introduced in 2014. To date, a total of 1,833 MOOCs have been actively offered to UiTM students and learners worldwide. The development of MOOC in UiTM is to support or replace the conventional face-to-face (F2F) learning (i-Learn Centre, 2016). At UiTM, students have the opportunity to utilize MOOCs as supplementary resources and study materials for review, given that the courses are aligned with the university's curriculum. Prospective and current students can preview courses offered by the university, providing insight before enrolling or beginning their academic journey (Aziz, 2018).

2.2 MOOC for Effective Learning of Electrical Energy Economics and Planning

Electrical Energy Economics and Planning is offered to students taking the Bachelor of Electrical Engineering Programme as an elective subject. This subject introduces the

BY-NC-SA 2024, Editorial Universitat Politècnica de València

economics aspects in power system in terms of its market requirement, effects of security and transmission to the electricity pricing and discusses the issues of investments in power generation and transmission equipment. However, engineering students commonly encounter difficulties when dealing with economic theories and concepts. This is primarily because these students often lack a robust background in economics, posing challenges in comprehending economic theories. Additionally, the intricacies of energy economics, intertwined with government policies and regulations, can be challenging for students with a predominant technical background. Moreover, the application of economic concepts to real-world energy scenarios proves challenging for engineering students accustomed to solving technical problems. Table 2 outlines the various ways in which the MOOC can enhance students learning in the energy economics course.

Table 2 – MOOC key charactteristics

MOOC Characteristics	Ways in Which MOOCs Can Boost Student Learning
Flexible Learning Schedule	Flexibility in terms of learning schedules, allowing engineering students to balance their coursework with the demands of their engineering curriculum.
Access to Diverse Learning Resources	A wide range of learning resources, including videos, readings, and interactive simulations, catering to different learning styles and preferences.
Interactive Learning Platforms	Incorporate interactive elements such as discussion forums, collaborative projects, and quizzes, fostering engagement and active participation.
Self-Paced Learning	The self-paced nature of MOOC allows students to revisit challenging concepts, ensuring a thorough understanding of economic principles at their own pace.
Real-World Applications	Can include case studies and practical examples that demonstrate the real-world application of energy economics concepts
Interdisciplinary Collaboration	Encourage interdisciplinary collaboration, enabling engineering students to interact with peers from economics backgrounds
Immediate Feedback	Interactive assessments in MOOCs provide immediate feedback, helping students understand and correct any misconceptions, reinforcing their learning.

Source: Own elaboration

3. Methodology

3.1 Overall Methodology

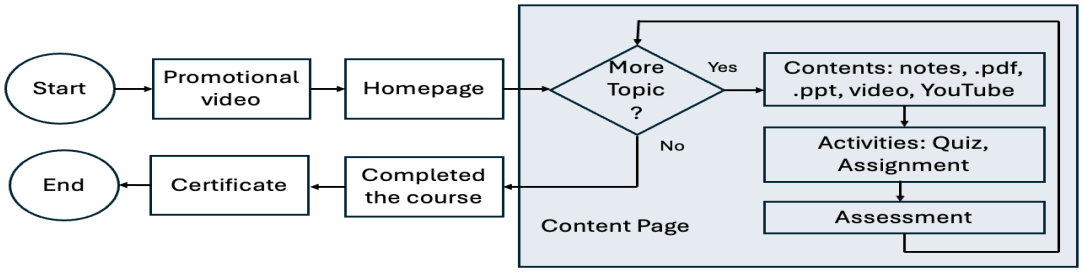
In essence, there are three main components in the MOOC development process: a homepage, often called a landing page, a content page and completion. Figure 1 shows the flowchart of developing MOOC in UiTM. Developers of MOOCs have the flexibility to structure their courses as mandated by the Guidelines for Development and Delivery of Malaysia MOOC (MOE, 2017). All UiTM MOOCs are hosted by OpenLearning platform and currently available at (UiTM MOOC, 2024).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3.2 MOOC Component Development

The first component i.e. homepage or landing page should include an introductory video presenting the course, a course synopsis, learning outcomes, prerequisite knowledge, details on course management, instructor information, the course's start date and duration. The second component i.e. content page should include breakdown of sub-topics, corresponding learning outcomes, educational materials, learning activities, assessment details, and additional reference sources. Table 3 an 4 describe the key elements in UiTM MOOC Homepage/landing page and content page (MOE, 2017).

Fig. 1 – Overall flowchart of MOOC development in UiTM



Source: Own elaboration

Table 3 – Description of key elements in UiTM MOOC Homepage/landing page

Key Element	Description
Promotional video	A video to promote the course with duration less than 1 minute
Course introductory video	A video to highlight course description, learning outcomes, list of topics, learning activities with duration less than 3 minutes.
Course synopsis	General information about the course, delivery format and learning outcomes
Course syllabus	Detail information, overall structure, learning activities and assessment
Course learning outcomes (CLO)	The knowledge and skills that the students will acquire after they complete the course
Prerequisite knowledge	Prior knowledge to ensure that learners have the necessary background
Immediate Feedback	Interactive assessments in MOOCs provide immediate feedback, helping students understand and correct any misconceptions, reinforcing their learning.

Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Table 4 – Description of key elements in UiTM MOOC content page

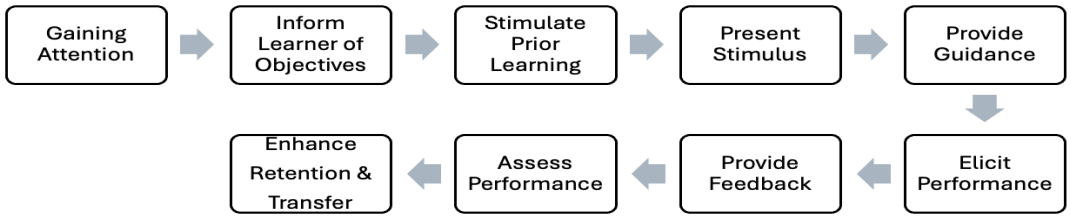
Key Element	Description
Sub-topics	Each topic can be divided into several subtopics
Topic learning outcomes (TLO)	The knowledge and skills that the students will acquire after they complete each topic. TLO must be aligned with the CLO
Learning contents	The instructional content can be in the form of videos, Podcase, Wiki/Blog, interactive content, e-book, webpage link and documents in .pdf, .doc, .ppt, etc.
Learning activities	Learning activities to enhance students' understanding, skills and values. Activities can be in the forms of discussion, forum, quiz, case studies, problem solving, e-portfolio, or any Web 2.0 tools
Assessment	Assessment should align with the CLO, aiming to gauge students' successful achievement of the learning outcomes
Additional references	Additional references can be in the forms of videos and links to websites

Source: Own elaboration

3.3 MOOC Instructional Design

The overall format of UiTM's MOOC incorporates Gagne's Nine Events of Instruction (Gagne, Briggs & Wager, 2005). The instruction encompasses nine sequential steps that assist course developers in organizing their content as in Figure 2. The model commences with "Gain Attention" to engage learners at the lesson's outset. "Inform Learner of Objectives" clarifies the expected achievements by the learning outcomes. "Stimulate Prior Knowledge" involves prompting existing relevant experiences or knowledge. Subsequently, "Present Stimulus" presents new knowledge in an organized manner through diverse instructional approaches. "Provide Guidance" aids comprehension by providing explanations, examples, or supplementary resources. "Elicit Participation" prompts active engagement through activities, discussions, and exercises. "Provide Feedback" furnishes prompt responses to learners' performance. Additionally, "Assess Performance" involves assessing learners' proficiency through various means, such as quizzes. Lastly, "Enhance Retention and Transfer" aims to apply knowledge to different contexts.

Fig. 2 – Gagne Nine Events of Instruction Model



Source: Own elaboration

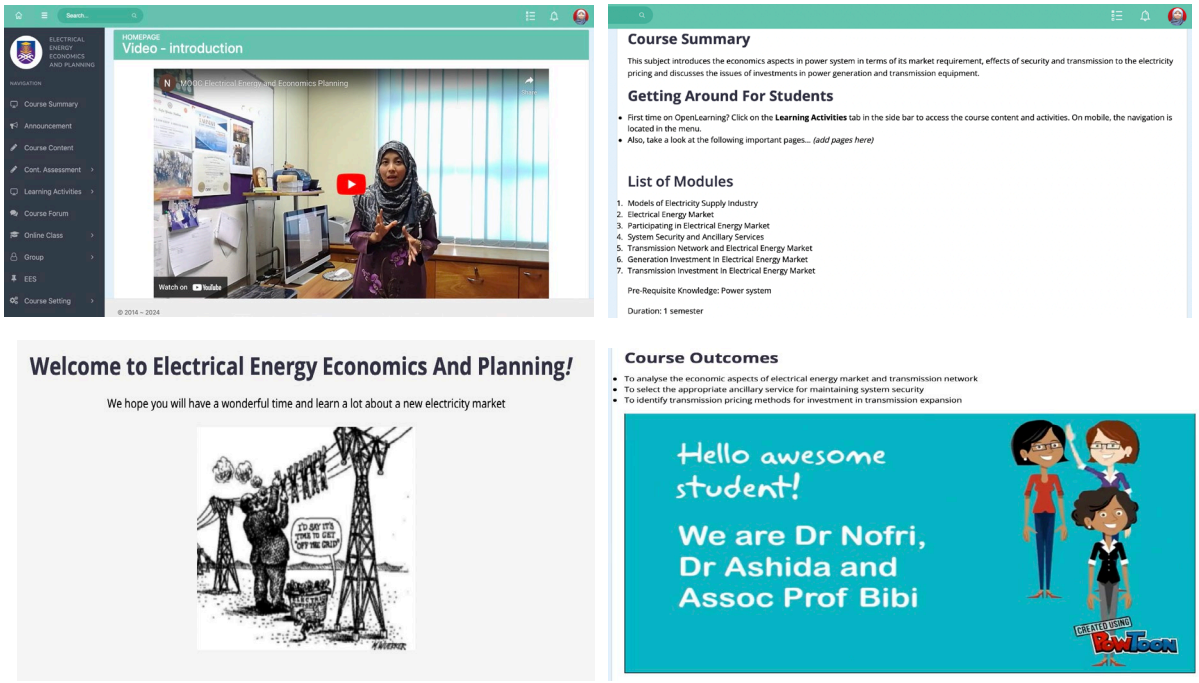
 BY-NC-SA

4. Result and Analysis

4.1 Components of Homepage/Landing Page

Figure 3 shows the Homepage/Landing Page designed for the course. An introductory video has been crafted to elucidate the course description, learning outcomes, the course's topic list, and the diverse learning activities available in this online program. Additionally, a lively Powtoon animated video introduces the instructors and underscores the key course content. The homepage is further enhanced with engaging animations, incorporating video elements and playful cartoon images to captivate the interest of learners.

Fig. 3 – Homepage/landing page



Source: Own elaboration

4.2 Components of Content Page

Figure 4 illustrates the Content Page of the course, featuring seven topics outlined in the course syllabus. These topics delve into the economic aspects of components within the electricity supply industry, covering energy market models, participants, system security, ancillary services, transmission network, and generation and transmission investment. Each topic in the course incorporates diverse learning content and activities, aligning with Gagne's Nine Events of Instruction, as depicted in Figure 5.

Within each topic page's content, emphasis is placed on highlighting the background and learning outcomes. A set of topic notes, presented in the form of a .ppt slide presentation, serves as the primary learning reference for students. Furthermore, various learning activities are integrated to enhance students' understanding, skills, and values. Typically, each topic

BY-NC-SA 2024, Editorial Universitat Politècnica de València

encompasses attention-grabbing elements, activities, tutorials, quizzes, and assignments, forming a part of the formative assessment. On the other hand, summative assessments are conducted through a final exam to evaluate students' overall understanding. Rubrics with specific criteria and clear expectations for learners is used for evaluating the assigments.

For each topic, a minimum of three activities is provided, incorporating real case studies, examples and discussion questions for students to engage with in groups. A forum platform is utilised to create student community. Lecturers play a crucial role to manage and moderate the discussion in facilitating collaborative learning. YouTube links to relevant videos are also incorporated to augment understanding and facilitate the sharing of actual cases. Following each activity, an online platform allows for immediate comments and feedback, fostering a dynamic questions and answers session. Figure 6 provides examples of the diverse learning activities designed to support interactive learning.

The effectiveness of MOOC will be evaluated using several strategies such as learning outcomes achievement through assessments that align with the CLO, completion rates of individual student, feedbacks from students through survey and performance improvement.

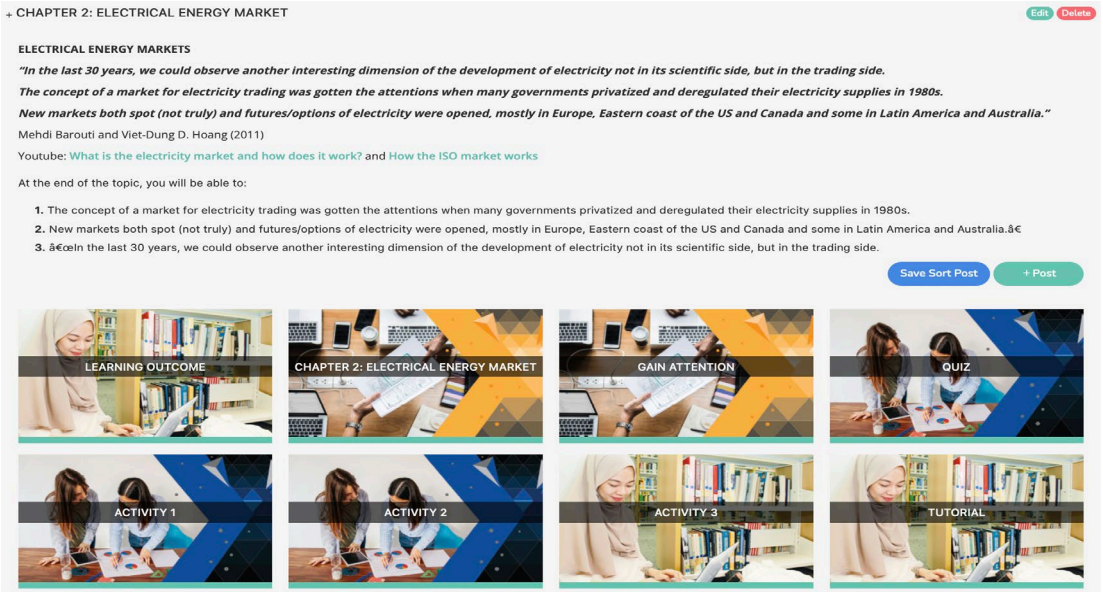
Fig. 4 – List of topics provided in the MOOC online course



Source: Own elaboration

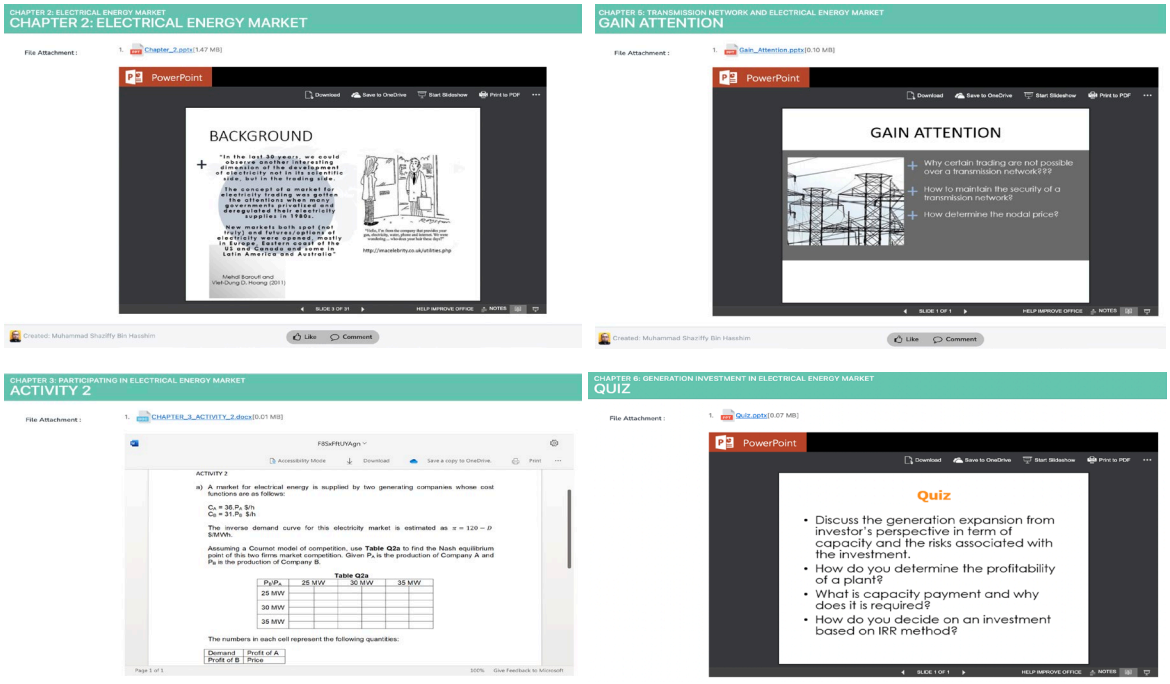
2024, Editorial Universitat Politècnica de València BY-NC-SA

Fig. 5 – Learning activities available for each topic



Source: Own elaboration

Fig. 6 – Sample of learning activites provided in the online course



Source: Own elaboration

5. Conclusion

In conclusion, designing a MOOC for effective learning in electrical energy economics and planning for engineering students requires careful consideration of various factors.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Throughout this paper, we provide a comprehensive develpment of course structure, content delivery, interaction mechanisms, assessment strategies, and instructor facilitation in ensuring a successful learning experience. By leveraging innovative instructional design principles, incorporating real-world case studies and simulations, promoting active engagement through discussions and collaborative projects, and implementing robust assessment methods. Subsequent efforts will focus on assessing the efficacy of the developed MOOC in attaining its learning objectives by analyzing data related to student outcomes, feedback/satisfaction, or learning advancements.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Anealka Aziz (2018). Evaluating the Design Standard of UiTM Massive Open Online Courses. *International Journal of Education & Literacy Studies*, 6 (4), 138-151. http://dx.doi.org/10.7575/aiac.ijels.v.6n.4p.138

Gagné, R. M., Briggs, L. J., & Wager, W. W. (2005). Principles of instructional design (5th ed.). Forth Worth, TX: Harcourt Brace Jovanovich College Publishers.

i-Learn Centre (2016). Garis panduan pembangunan e-kandungan kursus UiTM. Retrieved from http://i-learn.uitm.edu.my/v2/wp-content/uploads/2016/11/Buku_Garis_Panduan.pdf.

Jabatan Pendidikan Tinggi (2024). Massive Open Online Courses (MOOCs). Retrieved from https://jpt.mohe.gov.my/portal/index.php/ms/pelajar/massive-open-online-courses-moocs.

Ministry of Education (2015). Malaysia Education Blueprint 2015-2025 (Higher Education). Putrajaya: MOE.

Ministry of Education. (2017). Guidelines for development and delivery of Malaysia MOOC. Putra Jaya: BPPA.

UiTM MOOC (2024). Retrived from https://www.openlearning.com/uitm.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Institutional Policies and Higher Education in Sustainability Agenda

Nikolaos Taousanidis[a], Andreas Taousanidis[b]

[a]Department of Mechanical Engineering, University of Western Macedonia, Greece
[b]Technology Transfer Office, University of Western Macedonia, Greece

Abstract

The article is dealing with challenges faced by universities' efforts in meeting society's expectations for a sustainable world. By expanding the scope of universities' obligations, it underlines the negative effect of institutionalizing social goods and its implications on the functioning of universities as one of the leading actors in societal advancement. Scholars have not yet tackled in depth this issue as the methodology adopted for sustainability issues appears to align with the UN Sustainability Goals. By shifting focus from declining managerial practices to ethical values and the historical significance of universities, a pioneering role in sustainability agenda can be ensured. Suggestions are made on how state can provide support either through institutional or financial means to enable universities to not only contribute to achieving a sustainable future but also to reformulate the very notion of sustainable development. This article also emphasizes the strategies universities employ to accomplish these targets.

Keywords: sustainability; university; ethics; free will.

How to cite: Taousanidis,N.;Taousanidis, A. (2024) Institutional Policies and Higher Education in Sustainability Agenda. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 945-951. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

The concept of sustainability in scientific literature emerged during the 1980s. It initially focused on environmental protection and energy conservation, rather than the broader scope it encompasses in the present days. Previous research (Taoussanidis and Antoniadou, 2006) highlighted this diversification and the potential integration of sustainability into higher education. At present, a growing focus on contextualizing sustainability is witnessed similar to other social issues by establishing targets, guidelines (UNESCO, 2023), indicators (Gebara et al, 2024) and in general implementing managerial practices in it.

Tainter points out "our understanding of sustainability depends to a significant degree on our understanding of the human past" (Tainter, 2011). Human history taught us that sustainable living requires cooperation, ethics, morality, respect, and reverence for all forms of life on planet Earth. By upholding these fundamental values, sustainability can naturally emerge without the need for extensive institutional recommendations and guidance.

In the ongoing debate surrounding sustainability, higher education institutions hold a significant role much like their role on contributions to the advancement of other societal goods. Historically, universities have enjoyed academic freedom ("Constitutio Habita", University of Bologna) and pursued truth and imparted values fostering social progress and knowledge enhancement. Ethical vision has always been intertwined with efforts to address complex issues through the knowledge and technical skills they provide to students and graduates. Therefore, the debate on universities' role in promoting sustainability does not introduce something novel but rather reaffirms the inherent link between higher education and societal well-being. The question remains whether the global agenda on sustainability and the universities' obligation to align with it offers any novel contributions and insights to society and the common good.

2. The advancement of social values

Society's advancement is an ongoing process and ensuring sustainability is part of it. Instead of reinventing concepts already tackled and rediscovering ideas that have already been addressed, it is crucial to build upon our success and knowledge. A notable example is our admiration of isolated populations in various parts of the world, because of their appreciation of traditional values and principles, their respect for social relations and environment. On the contrary, we express concerns over the detrimental effects of modern practices on their civilization. In response, anxious international organizations eagerly organize panels and make commitments to support these communities worldwide, emphasizing the importance of sustainability.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The scientific community, independent of political influences can play a significant role in initiating discussions and raising public awareness for all historically grounded practices, integrating then in everyday life. Higher education institutions, as the providers and custodians of scientific knowledge, can in turn create professionals who possess a broader perspective and a wider range of skills and capabilities. We are convinced that providing free education, fostering free will and encouraging freedom of thought among students, combined with an emphasis on humanitarian values can ensure a high quality of life for future generations. Faculty members should only intervene to harmoniously incorporate the concept of sustainability into scientific and technological achievements. However, this has always been an integral part of the university learning procedure. Thus, it is more relevant to address the challenges faced by society, politics, and economy withing this procedure rather than aligning the universities with specific agenda. Boron, underlining the teaching dimension, supports that "The ultimate purpose of academic teaching programs orientated around 'sustain-ability' is to support the practical attainment of a sustainable future for industry, business, and society" (Boron et al, 2017).

However, the contextualization of sustainability principles poses challenges to universities' operations in addressing these issues. For instance, the institutionalization of pollutant concentration limits serves as s referral point: policymakers decide certain pollutant emission targets and feel satisfied when large companies comply with the new rules, regardless of potential negative impacts on labor rights and salary levels. Furthermore, the issue is worsened by geographical compartmentalization, such as when Europe takes pride in aligning with UN goals (UN, 2015) while as a continent has already been de-industrialized and relies heavily on "polluting" countries for all the products they consume. In such cases the concept of sustainability is definitely not upheld. This is not what higher education institutions serve and it is necessary for universities to introduce and advocate for social justice principles in all the spectrum of their activities. However, this task is considerably challenging in the absence of public funding and with private funding prioritizing financial profits over humanitarian values. In addition, there is a tendency for universities to cultivate graduates who are compliant with corporate hunger rather than fostering a sense of social responsibility.

3. Discussion

The above analysis does not intend to diminish the efforts of international community, particularly the UN Agenda. Instead, it underlines the fact that managerial practices and agreements on budgetary issues alone are insufficient to solve social issues. The UN Declaration for Human Rights, which was adopted in 1948, unfortunately does not guarantee yet that humanity as a whole is able to enjoy these rights. This is a concerning issue that needs to be addressed. Additionally, as stated by Tainter (1995) the escalation of institutional

BY-NC-SA 2024, Editorial Universitat Politècnica de València

complexity "is likely to bring increased complexity, higher costs, and diminishing returns to problem solving".

As far as higher education is concerned, it is important to acknowledge its historical role as the lead actor working towards a better future for society (Cortese, 2003). However, the question arises as to whether the contemporary political system allows higher education institutions the freedom to fulfill their mission, utilizing their expertise and knowledge. While funding is a crucial aspect, as mentioned before, it is not solely a matter of financial resources. Any limitation imposed on universities in terms of resources, procedures and public assessment hinder their ability to fulfill their missions effectively.

The state has a responsibility to provide institutional support to universities. The first step of appreciation should be shown on the way the state legally protects higher education and values universities' proposals. Additionally, enhancing their prestige, involving them in advisory boards and supporting their local and international partnerships offer higher education institutions a broader perspective and enable them to focus on their role effectively. Ensuring that individuals have the right to access higher education, without any prerequisites other than their desire and capabilities, is an important institutional measure, the state should take.

Secondly, it is imperative for the state to provide financial support to universities. Taking into consideration the universities' responsibility for public accountability, we advocate for funding that is not arbitrary but rather essential for the accomplishment of university objectives. The pressure for market – oriented education and research may potentially undermine the core mission of higher education and therefore rational public funding, whether from national or international funds, is crucial for ensuring the autonomy and independence of universities.

Numerous discussions have revolved around state's obligations to universities, but it is necessary to acknowledge that universities also bare their own responsibilities. While strategic plans and institutional missions are available on home page of any university's website emphasizing the obvious that they are universities aimed to "respond to societal expectations to address environmental, social cultural and economic issues" (Shephard, 2015), we address deeper at the transformation of mental models (Wals, 2002). The everyday practices of faculty members along with the supporting administration to inspire students, to transfer the knowledge stock of human accomplishments towards a better life and to prepare students to tackle global challenges rather than being solely focused on local and regional priorities. The teaching and research framework should be structured in a manner that respects the traditional values while also explore innovative approaches to better serve the community. As Jorgensen et al (Jorgensen et al., 2019) points out "the field of sustainability transitions embraces a sociotechnical systems perspective that integrates research on

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

technological innovation, social sciences and policy". Encouraging students to engage in social networks fosters a sense of collective action and engagement in sustainability efforts (Stapleton, 2015). "Sustainability is not a condition of stasis. It is, rather, a process of continuous adaptation, of perpetually addressing new or ongoing problems and securing the resources to do so" (Tainter, 2011) and graduates must always have that in mind.

Additionally, universities worldwide have the privilege to engage in communication and collaboration in various ways due to their shared commitment to societal responsibilities. They share knowledge, expertise, faculty members and students, they participate in international programs and initiatives and utilize resources in a collective manner. Furthermore, in addition to their similar actions, universities also possess a global mindset, accessing the world's cultural wealth. An excellent example of this cultural wealth is the understanding and practice by earlier generations of circular economy, a contemporary approach and scientific field. In traditional agricultural areas the families generated almost zero waste as materials were recycled back in the production chain. This approach should guide the way universities addressing and confronting challenges as "sustainability is a matter of solving problems" (Tainter, 2011).

Exploring the implications of overconsumption and its undesirable (or desirable for some) consequences would exceed the scope of this study. However, it is evident that sustainability and overconsumption are incompatible with each other. This principle is incorporated in the engineering curricula through the discussion of energy conservation, energy efficiency and even more in the entropy concept analysis. Nevertheless, scientific areas such as Marketing, Banking, and Finance face difficulties in adopting similar approaches, not due to their background and nature but because of their market – driven applications. An interdisciplinary approach would enrich knowledge in these fields by exposing students to information on theories and concepts beyond narrow perspectives.

Another phenomenon emerged in contemporary policies is the institutionalization of various aspects that people find meaningful whether it is beliefs, values, or behaviors. This results in the establishment of bureaucratic organizations that oversee and regulate these aspects, ultimately diminishing the potential impact universities could have on addressing societal challenges. Instead of fostering free critical thinking and open debate, this trend leads to the fragmentation of knowledge and the contextualization of human values. This process presents itself as the patron for society, claiming safeguarding of societal achievements, particularly in terms of promoting sustainability but practically, it functions as a form of concession. Institutions focused on sustainability present it as a challenge for an endangered world setting specific targets and providing and providing a roadmap for achieving them. In

BY-NC-SA 2024, Editorial Universitat Politècnica de València

terms of the universities' role, there is a push towards higher education to conform and align to the guidelines set forth by these institutions.

4. Conclusion

All these lead to the conclusion that traditional values, civilization appreciation, and respect for human nature are essential for nurturing prosperity, suggesting that it is utopic to believe that institutional practices alone are able to ensure sustainability without these foundational values. The recognition that "our implicit and explicit denial of (history's) importance has a negative influence on our ability to become sustainable" (Tainter, 1995) is of paramount importance and underlines the critical significance of upholding these values.

Placing universities in the position of executive bodies, obliged to governmental and transnational organizations, poses a major threat not only to sustainability but also to the future of humanity. This shift implies that universities must align their practices with the agendas of organizations, which claim that act democratically and use higher education to legitimize their actions, compromising the universities' autonomy and integrity in the meantime.

Universities are entrusted with a societal mission to prioritize teaching, scientific research, and community engagement fostering a culture of free but responsible willing and equipping graduates with the necessary skills and tools to envision a fair and prosperous world. However, this educational mission should be accompanied by fundamental changes in attitudes, values, lifestyles, and narratives to truly effect positive change (UNESCO, 2023).

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Boron, S., Murray, K.R., Thomson, G.B. (2017). Sustainability education: towards total sustainability management teaching. In: Filho WL, Brandli L, Castro P, Newman J (eds), Handbook of theory and practice of sustainable development in higher education, vol 1, 37–52. https ://doi.org/10.1007/978-3-319-47868 -5

Cortese, A.D. (2003). The critical role of higher education in creating a sustainable future. *Planning for Higher Education*, 31(3):15–22. https://www.redcampussustentable.cl/wp-content/uploads/2022/07/6-CorteseCriticalRoleOfHE.pdf

2024, Editorial Universitat Politècnica de València BY-NC-SA

Gebara, C., Thammaraksa, C., Hauschild, M., Laurent, A. (2024). Selecting indicators for measuring progress towards sustainable development goals at the global, national and corporate levels, Sustainable Production and Consumption 44(2024) 151-165 https://www.sciencedirect.com/science/article/pii/S2352550923002786

Jorgenson, S., Stephens, J., White, B., Environmental education in transition: A critical review of recent research on climate change and energy education, *The Journal of Environmental Education*,. 50(3), 160–171

https://www.tandfonline.com/doi/full/10.1080/00958964.2019.1604478

Shephard, K. (2015) Higher education for sustainable development. Palgrave Macmillan, UK

Tainter, J. A. (1995). Sustainability of complex societies. *Futures* 27, 397–407. https://www.sciencedirect.com/science/article/pii/001632879500016P

Stapleton, S. (2015) Environmental Identity Development Through Social Interactions, Action, and Recognition, The Journal of Environmental Education, 46(2), 94-113. https://www.tandfonline.com/doi/full/10.1080/00958964.2014.1000813

Tainter, J. A. (2011). Energy, complexity, and sustainability: A historical perspective. *Environmental Innovation and Societal Transitions*, 1(1), 89–95. https://www.sciencedirect.com/science/article/pii/S221042241000002X?via%3Dihub

Taoussanidis, N. and Antoniadou, M. (2006). Sustainability development in REngineering education, *Industry & Higher Education*, 20 (1),35-41.

United Nations Educational, Scientific and Cultural Organization (2023). General Guidelines for the Implementation of Sustainability in Higher Education Institutions. https://www.un.org/sites/un2.un.org/files/unai_sdgs_guidelines_updated.pdf

United Nations General Assembly. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. https://documents-dds-ny.un.org/doc/UNDOC/GEN/N15/291/89/PDF/N1529189.pdf?OpenElement

Wals A. (2002) "Sustainability" in higher education - From doublethin and newspeak to critical thinking and meaningful learning, *International Journal of Sustainability in Higher Education*, 3 (3), 221-232

https://www.emerald.com/insight/content/doi/10.1108/14676370210434688/full/html

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Sustaining Authentic Assessment (AA): A pilot survey of student perceptions of AA to improve higher order thinking and employability

Judy Rose[a] and Adis Duderija[b]

[a]Griffith Institute for Educational Research/Office of the Pro-Vice Chancellor, Arts, Education and Law, Griffith University, Australia

[b]Centre for Social and Cultural Research/School of Humanities, Languages and Social Science, Griffith University, Australia

Abstract

Authentic assessment (AA) is a reform in higher education that has been less explored from students' perspectives. In this paper we report findings from a pilot study that explored student perceptions of authentic assessment in the Islam West Relations Major (IWRM) Bachelor of Arts program, at an Australian university. This study used a survey that the authors created to explore two aspects of AA including its capacity to 1) develop higher order thinking skills, and 2) improve employability of students. In addition to surveying student's attitudes towards AA, this study is the first to ask students to suggest alternative forms of authentic assessment. Students recommended oral presentations, government submissions, briefing papers, study tours, and cross-cultural interviews as providing skills they perceived relevant to their future careers. In contrast, students rated exams, quizzes, and tutorial readings as the least helpful form of knowledge evaluation in terms of higher order thinking and employability skills. Initial findings indicate that undergraduate students show support for authentic assessment, as it develops skills transferable to the workplace and their future careers. Finally, AA is best integrated at both program and curriculum levels as a sustainable education model. This model focuses on developing higher-level critical and creative thinking skills that equip graduates to work on, and find solutions for, complex world problems.

Keywords: authentic assessment; higher order thinking; employability; sustainable education; mixed analysis.

How to cite: Rose, J.; Duderija, A. (2024) Sustaining Authentic Assessment (AA): A pilot survey of student perceptions of AA to improve higher order thinking and employability. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 952-960. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Assessment is the most significant factor that impacts the quality of student learning in higher education (Bryan & Clegg 2019). Research has found that the nature of assessment strongly influences 'what and how learners' study at university (Villarroel et al., 2020: 39); and impacts student satisfaction levels (James & Casidy., 2018). In higher education there is growing awareness that assessment needs to be more meaningful to students, including relevant to their future employment and careers (Andrews & Higson, 2008; Wu et al., 2015).

The OECD Future of Education and Skills 2030 report has emphasized that, 'creativity and critical thinking are needed to find solutions to complex problems' (OECD, 2019: 5). The report highlights the need for graduates to have well-developed analytical skills to tackle problems, such as climate change and food insecurity (Cross & Congreve, 2021; Worosz et al., 2020). Within the sustainable higher education movement (Boud & Soler, 2016) which moves the focus away from disciplinary knowledge to what students do in real life, there is greater emphasis on teaching of higher order thinking (HOT) skills and problem-solving assessment (Karyotaki & Drigas, 2016). However, the shift to a paradigm of assessment for learning, rather than measurement of learning, has been volatile (Goos, 2011; Manville, 2022).

One pedagogical approach that has potential to develop students' higher-level skills is authentic assessment (Ozan, 2019; Villarroel et al. 2018). Authentic assessment tasks generally assist students to access cognitive (e.g., analytical thinking), creative (e.g., finding solutions for complex problems), methodological (e.g., applying digital techniques), and social domains (e.g., working in cross disciplinary/cultural teams); to solve real life problems (Herrington et al., 2010). AA tasks often approximate or simulate work-like environments, have work integrated learning components, or deal with authentic issues (Ellis et al., 2020; Lasen et al., 2018; Green et al., 2022). Yet, little is known about what students think of AA.

To date, limited research has explored university students' perceptions of authentic assessment (AA). James and Casidy (2018) study found that authentic assessment increased student satisfaction with their subject of study, although this was based on hypothetical assessment scenarios rather than completed assessment tasks. An earlier study by Cassidy (2006) found students regarded peer assessment to be a meaningful preparation for employee reviews in the workplace. Another study by Arsenis et al. (2021) found students valued group video tasks for developing teamwork and communication skills that would be useful for future jobs. Problematically, most previous literature has focused on what course designers and instructors consider as authentic assessment in higher education (e.g., Maclellan, 2004; Ozan, 2019). For this paper we report on findings from a pilot study we designed to conduct an initial investigation into Bachelor of Arts students' perceptions of AA. The main research question is: What kinds of assessment do students perceive as authentic in terms of 1) developing higher order thinking skills, and 2) employability?

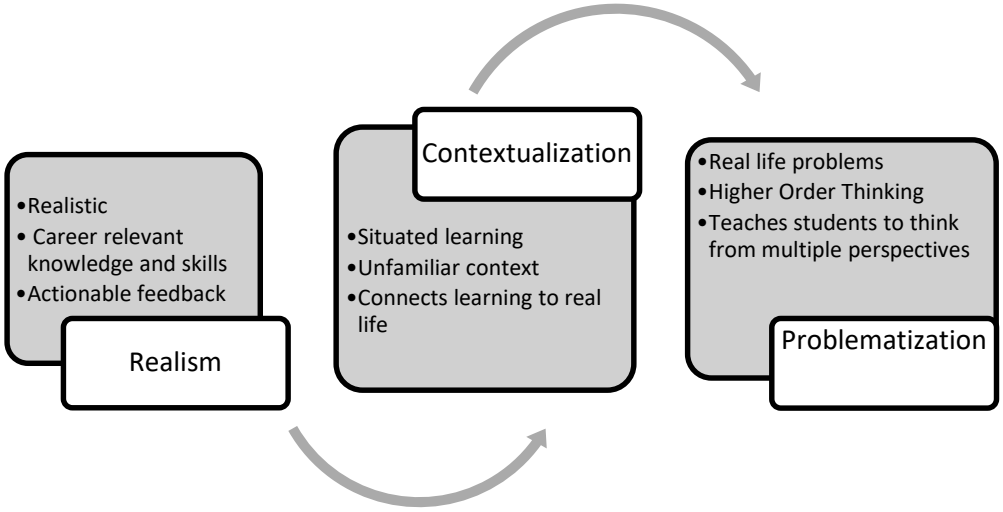
BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Conceptualising Authentic Assessment

Although there is no single definition for authentic assessment, it can be understood as "a way to relate learning and work, creating a correspondence between what is assessed in the university and what graduates do in settings in the outside world" (Villarroel et al., 2020, 40). Similarly, Deneen (2024) regards AA as extending beyond the academic program to emulate meaningful experiences in the broader context of people's lives. A set of criteria developed from a systematic review of the literature conducted by Villarroel et al. (2018) identifies three key characteristics for AA: 1) having a practical purpose and value beyond the classroom, 2) improving student abilities to solve problems that exist in real life, and 3) providing relevant skills for successful job performance (Villarroel et al., 2018).

Villarroel et al. (2020) recommend AA incorporate aspects of realism, contextualization, and problematization. Realism enables students to link knowledge learned in class with real life situations; for example, examining food waste issues to create a strategic plan for a restaurant manager (Steriopoulos et al., 2022). Contextualization requires instructors to assess student knowledge in a contextually relevant ways such as via work-integrated learning placements that involve having students write up a reflection on their developing professional identities (Green et al., 2022). Problematization incorporates problem-based learning that is applied to real life situations. For example, an assessment task for engineering students required them to work in team to find renewable energy solutions in different kinds of communities in Columbia (Colmenares-Quintero et al., 2023). Deneen (2024) suggests the aim of AA is to develop students' capacity to apply higher order cognitive skills using realistic practices and contexts that promote thinking from multiple perspectives. Figure 1 demonstrates a conceptual framework for AA, adapting elements from Deneen (2024) as well as Villarroel and colleagues (2018; 2020) to illustrate key features of AA.

Figure 1 – Conceptual Framework for Authentic Assessment



Sources (Deneen, 2024; Villarroel et al., 2018, 2020)

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

3. Study Aim and Method

This study aimed to conduct an initial exploration into the perceptions of authentic assessment from a learner's perspective, for a group of students who had completed an Islam-West Relations major (IWRM). The IWRM refers to Islam-West Relations Major and is part of Bachelor of Arts (BA) degree offered at a university in Brisbane, Australia. In 2021, the authors co-designed an online survey consisting of 15 questions asking about two aspects of authenticity; its capacity to develop higher-order thinking (HOT) skills and be relevant to student's future work. Then, the authors validated the survey qualitatively following steps suggested by Artino and colleagues (2014). This started with a targeted literature review followed by discussions to check for relevance, clarity and interpretability of survey items. (A copy of the survey is available via DOI: 10.13140/RG.2.2.21100.17284).

4. Recruitment and Sample

Respondents were recruited via an existing online group that comprised of self-referred past and current IWRM students. Twelve participants who had completed the IWRM as part of their Bachelor of Arts Degree, completed the survey. Although 12 is a relatively small sample size, it was considered sufficient for a related HEA fellowship action research project. The survey respondents spent an average of 42 minutes to complete, indicating that the quality of responses was high. The sample comprised of 67 per cent male, 33 per cent female. The majority (91.7 per cent) were young, aged between 25-34 years, while 8.3 per cent were aged over 35 years. Most students (66.6 per cent) had completed the IWRM completely (i.e., 7 subjects) while others had taken 3 to 5 courses.

5. Analytic Strategy

To analyze the survey, we applied a mixed analysis strategy that uses both qualitative and quantitative techniques to analyze the survey under the unifying conceptual framework of AA (Rose et al., 2023). Mixed analysis works with a single data set (e.g., survey or interviews) and applies qualitative and quantitative analysis to that data. This entailed qualitative analysis of responses to open-ended questions combined with descriptive statistical analysis of close-ended responses. The analysis of open text box responses used qualitative descriptive research methodology to interpret findings (Sandelowski, 2010). For this paper we only report results from assessment that students rated highest (top three) and lowest (bottom three) in terms of authenticity criteria. The range of assessment items covered written, oral, online, tutorial, quiz, and examinations.

6. Results

Table 1 shows the top three most highly rated forms of assessment students perceived helped to develop higher order thinking skills. First, was *Essay Major* (58 per cent 'a lot,' 33 per

BY-NC-SA 2024, Editorial Universitat Politècnica de València

cent 'most'). Combined, these two categories represented 91 per cent of students' views on this assessment task. Second, was *Research Article* (42 per cent 'a lot,' 33 per cent 'most'). Combined, they represented 75 per cent of respondent's views on this assessment task. Third, was *Essay Minor* (66 per cent 'a lot,' 8 per cent 'most'). Combined, these two categories represented 74% of respondent's views. Overall, students perceived written assessments as most effective in developing their higher-order thinking skills.

Table 1. Assessment Students Perceive Assists Higher Order Thinking

	Not at all	Somewhat	A lot	Most	N/A	Total (%)
Essay Major		8%	58%	33%		100
Research Article		8%	42%	33%	17%	
Essay Minor	8%	16%	66%	8%		100

N/A = respondent did not do this form of assessment

Source: Own elaboration

The following comments illustrate the link between highly rated written assessments and the development of higher order thinking skills:

> *Long form essays assisted me in developing research and communication skills that lent to the development or higher order thinking skills [Respondent 10]*
>
> *I believe that relying most heavily on essays and research papers can develop the higher-order thinking skills, particularly for undergraduates [R. 6]*

These student comments underscore the perceived value of written assessment tasks in cultivating HOT among IWRM undergraduates.

Next, we report on assessments students perceived to be relevant to their future employment. Results in Table 2 indicate these to be *Essay Major* (67 per cent 'a lot' and 17 per cent 'most' - 84 per cent combined). Second was *Research Article* (42 per cent 'a lot' and 33 per cent 'most' - 75 per cent combined). The third was *Essay Minor* (75 per cent 'a lot'). These findings are similar to assessments students perceived developed HOT.

Table 2. Assessment Students Perceive Relevant to Future Employment

	Not at all	Somewhat	A lot	Most	N/A	Total (%)
Essay Major	8%	8%	67%	17%		100
Research Article	8%	8%	42%	33%	8%	100
Essay Minor	8%	17%	75%			100

N/A = respondent did not do this form of assessment

2024, Editorial Universitat Politècnica de València BY-NC-SA

Overall, students overwhelmingly viewed essay-based and research-focused assessments as most beneficial for developing HOT and preparing them for future careers. The following comments show how students regard these forms of written assessment as providing job-ready skills.

> *I found that both the research article and essays were the most helpful forms of assessment for my desired area of employment. This is because research skills are helpful to master for a policymaking context [R. 7]*
> *I strongly believe that my essay writing skills will contribute to me getting a job. [R. 3]*

Table 3 shows the forms of assessments students recommended lecturers set for enhancing student employability were *Oral Presentation* and *Research Article* (58 per cent 'recommended' and 42 per cent 'highly recommended'**).** Following this was the *Journal Article* whereby (42 per cent 'recommended' and 50 per cent 'highly recommended' - 92 per cent combined). These results suggest that students want assessment to develop skills directly relevant to what is required future careers. While essay tasks provided skills that students valued, they preferred lecturers to set genres that are used in workplaces.

Table 3. Assessment Students Recommend Lecturers Set for Employability

	Do not Recommend	Recommend	Highly Recommend	Total (%)
Oral Presentation		58%	42%	100
Research Article		58%	42%	100
Journal Article	8%	42%	50%	100

Source: Own elaboration

The following comments address assessment tasks, activities, and skills that students perceive increase employability.

> *The Oral Presentation was quite an intimidating piece of assessment… I believe that experience provided me with the confidence necessary to approach job interviews as well as being receptive to criticism and collaborative efforts in the work environment [R. 4]*

> *I think a practical element of a course, such as … engaging with community members who have limited understanding of Islam, could be beneficial [R. 1]*

> *The [IWRM] course teaches critical thinking, research, analysis and communications skills that can be adapted across multiple areas of employment' [R. 2].*

BY-NC-SA 2024, Editorial Universitat Politècnica de València

7. Discussion and Conclusion

This study explored students' perceptions of authentic assessment to investigate its capacity to develop higher order thinking and relevance to future careers. Exploring student perceptions of authentic assessment has required greater attention according to our review of the literature, and doing so within a Bachelor of Arts program, Islamic-West Relations Major, offers a new contribution to the AA field as, '… Islamic studies programs in Australia were only established in the last decade.' (Rane et al., 2021, p.2).

The key takeaway from this pilot study is that students prefer assessment formats directly aligned with workplace practices (e.g., briefing papers, research articles, oral presentations) over more traditional academic genres (e.g., quizzes and exams). Recent research has found the use of 'viva' (oral form of assessment) is a useful tool for AA as it requires students to demonstrate or apply knowledge and skills in-situ or in face-to-face settings (Harper et al, 2021). As exams and quizzes typically requires a single correct answer, they are not well suited to problems that require multiple solutions (Boud & Soler, 2016; Weiss, 2003). Further, examinations (set under traditional exam conditions) are not usually ideal for assessing complex cognitive thinking (Kelly et al., 2022), although research suggests they can be more carefully designed to do so (Villaroel et al. 2020).

In conclusion, there are benefits and challenges in providing AA to foster 'engagement with real world problems' (Cross & Congreve, 2021: 496). A sustainable AA focus means that 'students should be given tasks that develop and test the skills and practices that they will need in their future careers–tasks that mirror professional practice and test more than just rote memorization' (James & Casidy, 2018: 401). This may require more effort from educators who may have relied mainly on traditional forms of assessment to assess undergraduates. To enhance sustainability of AA, experts suggest leadership is needed at an institutional level to implement strategies, build resources, and develop policy across the university (Deneen, 2024). At a program level (e.g. Bachelor of Arts), there needs to be regular consultation, evaluation and training for both students and staff to implement AA successfully and in a sustainable manner (Daneen, 2024).

Finally, the main limitation of our study was the short HEA Fellowship action research timeframe (12 weeks) which limited our sample size. As an unfunded project there was no financial incentive for students to complete the survey. Thus, findings cannot be generalized. In the future it would be beneficial to disseminate the survey to a wider population of students.

Acknowledgements

No funding has been received for the development of the research. It was part of a Higher Education Academy (HEA) Fellowship action research project. Ethics (GU Ref No: 2021/255).

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Andrews, J., & Higson, H. (2008). Graduate employability, "soft skills" versus "hard" business knowledge: A European study. *Higher Education in Europe*, *33*(4), 411–422. https://doi.org/10.1080/03797720802522627

Arsenis, P., Flores, M., & Petropoulou, D. (2021). Enhancing graduate employability skills and student engagement through group video assessment. Assessment & Evaluation in Higher Education, 47(2), 245-258. https://doi.org/10.1080/02602938.2021.1897086

Artino, A. R., La Rochelle, J. S., Dezee, K. J., & Gehlbach, H. (2014). Developing questionnaires for educational research: AMEE Guide No. 87. *Medical Teacher*, 36(6), 463–474. https://doi.org/10.3109/0142159X.2014.889814

Cassidy, S. (2006). Developing employability skills: Peer assessment in higher education. *Education + Training*, *48*(7), 508–517. https://doi.org/10.1108/00400910610705890

Colmenares-Quintero, R. F., Caicedo-Concha, D. M., Rojas, N., Stansfield, K. E., & Colmenares-Quintero, J. C. (2023). Problem based learning and design thinking methodologies for teaching renewable energy in engineering programs: Implementation in a Colombian university context. *Cogent Engineering*, *10*(1), 2164442. https://doi.org/10.1080/23311916.2022.2164442

Cross, I. D., & Congreve, A. (2021). Teaching (super) wicked problems: Authentic learning about climate change. *Journal of Geography in Higher Education*, *45*(4), 491–516. https://doi.org/10.1080/03098265.2020.1849066

Deneen, C. (2024, March 28). Right, real, focused: How authentic assessment can function in higher education [Webinar]. University of South Australia.

Ellis, C., Van Haeringen, K., Harper, R., Bretag, T., Zucker, I., McBride, S., Rozenberg, P., Newton, P., & Saddiqui, S. (2020). Does authentic assessment assure academic integrity? Evidence from contract cheating data. *Higher Education Research & Development*, *39*(3), 454–469. https://doi.org/10.1080/07294360.2019.1680956

Green, E., Hyde, S., Barry, R., Smith, B., Seaman, C. E., & Lawrence, J. (2022). Placement Architectures in Practice: An Exploration of Student Learning during Non-Traditional Work-Integrated Learning in Rural Communities. *International Journal of Environmental Research and Public Health*, *19*(24), 16933. https://doi.org/10.3390/ijerph192416933

Harper, R., Bretag, T., & Rundle, K. (2021). Detecting contract cheating: Examining the role of assessment type. *Higher Education Research & Development*, 40(2), 263–278. https://doi.org/10.1080/07294360.2020.1724899

Herrington, J., Reeves, T.C. & Oliver, R. (2010). A Guide to Authentic E-learning, Routledge, London.

Karyotaki, M., & Drigas, A. (2016). Latest Trends in Problem Solving Assessment. *International Journal of Recent Contributions from Engineering, Science & IT (iJES)*, *4*(2), 4. https://doi.org/10.3991/ijes.v4i2.5800

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Kelly, A., Moore, C., & Lyons, E. (2022). *Traditional exams, 21st century employability skills and COVID-19: Disruptive opportunities for rethinking assessment design in higher education.* STAR Scholars.

Maclellan, E. (2004). Authenticity in assessment tasks: A heuristic exploration of academics' perceptions. *Higher Education Research & Development*, *23*(1), 19–33. https://doi.org/10.1080/0729436032000168478

Manville, G., Donald, W. E., & Eves, A. (2022). Can Embedding Authentic Assessment Into the Curriculum Enhance the Employability of Business School Students? *GiLE Journal of Skills Development*, *2*(2), 73–87. https://doi.org/10.52398/gjsd.2022.v2.i2.pp73-87

Organization for Economic Co-operation and Development (OECD). (2019). The future of education and skills: Education 2030. *https://www.oecd.org/education/2030-project/*

Ozan, C. (2019). Authentic assessment increased academic Achievement and attitude towards the educational measurement of prospective teachers. *International Journal of Evaluation and Research in Education*, *8*(2), 299-312. https://doi.org/10.11591/ijere.v8i2.18564

Rane, H., Duderija, A. & Mamone, J. (2021). 'Islamic Studies in Australia's Higher Education Sector.' *Australian Journal of Islamic Studies* 6 (1), 1-31.

Rose, J., Low-Choy, Katz, I & Homel, R. (2023*).* 'Enriching Thematic Analysis with Clustering Techniques: Applying Mixed Analysis to Interviews About Big Data Linkage.' In R. Cameron & X. Golenko (Eds.), *Handbook of Mixed Methods Research in Business and Management*. Cheltenham, UK: Edward Elgar.

Steriopoulos, E., Goh, E., & Harkison, T. (2022). Practical teaching tips on designing authentic assessments in Tourism, Hospitality and Events (THE) higher education. *Journal of Teaching in Travel & Tourism*, *22*(4), 425–433. https://doi.org/10.1080/15313220.2022.2096181

Weiss, R. E. (2003). Designing problems to promote higher-order thinking. *New Directions for Teaching and Learning*, (95), 25–31. https://doi.org/10.1002/tl.109

Villarroel, V., Bloxham, S., Bruna, D., Bruna, C., & Herrera-Seda, C. (2018). Authentic assessment: Creating a blueprint for course design. *Assessment & Evaluation in Higher Education*, *43*(5), 840–854. https://doi.org/10.1080/02602938.2017.1412396

Villarroel, V., Boud, D., Bloxham, S., Bruna, D., & Bruna, C. (2020). Using principles of authentic assessment to redesign written examinations and tests. *Innovations in Education and Teaching International*, *57*(1), 38–49. https://doi.org/10.1080/14703297.2018.1564882

Worosz, M. R., Farrell, B., & Jenda, C. A. (2020). Teaching critical thinking via the "wicked problem" of food insecurity. *Portal: Libraries and the Academy*, *20*(4), 621–653. https://doi.org/10.1353/pla.2020.0030

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

A study of problem-based learning in higher education with a focus on sustainability degree programmes

Semih Severengiz[a], Stephan Sommer[a], Michelle Hoffmann[a] and Ann Kathrin Stinder[a]

[a]Bochum University of Applied Sciences, Germany

Abstract

Sustainable development requires innovative educational approaches, particularly in higher education, to connect academic learning with real-world challenges. Problem-Based Learning (PBL) has emerged as a prominent method. This paper examines the implementation and effectiveness of PBL, alongside related methodologies like project-oriented learning (POL) and research-based learning (RBL), in university education. Surveys conducted among students and professors at Bochum University of Applied Sciences assess the impact of PBL on learning, research outcomes, and engagement. Results show a positive perception among participants regarding the promotion of critical competencies such as analytical skills and solution orientation. Despite concerns about its time intensity, PBL is recognized for fostering deep understanding and collaborative problem-solving. While students appreciate the learning outcomes, professors highlight the alignment between course content and research projects. Challenges include the need for clearer student guidance and the time commitment required from professors. In summary, PBL is a valuable educational tool that enhances student engagement and proficiency in addressing real-world issues, thereby advancing sustainable development goals in higher education.

Keywords: Problem-based learning; higher education; sustainable development; project-based learning; research-based learning.

How to cite: Severengiz, S.; Sommer, S.; Hoffmann, M. and Stinder, A.K. (2024) A study of problem-based learning in higher education with a focus on sustainability degree programmes. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 961-969. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In higher education, practical teaching concepts based on projects involving specific problems and research questions are playing an increasingly important role in a large number of degree programmes. In addition to the methodological and academic education of students, skills such as independent problem solving and critical thinking are becoming increasingly important. In sustainability sciences and therefore in degree programmes with a strong focus on sustainability, these skills play a particularly important role and are often taught in the curriculum by means of interdisciplinary and transdisciplinary project studies. Successfully teaching these skills and assessing the results poses major challenges for both students and lecturers. In the realm of higher education, particularly university classes, there is a growing recognition of the necessity to connect academic learning with real-world problems and actors. In their research, Steiner and Posch (2006) conducted case studies to explore how an unconventional learning approach can enhance the teaching of sustainable development. Their findings indicate a need to redefine scientific expertise and reevaluate top-down approaches, especially in addressing real-world problems within the educational framework. They advocate for a departure from traditional teaching methods and emphasize the importance of incorporating these innovative approaches (Steiner and Posch 2006).

Since the complexity of topics related to sustainability requires innovative didactic approaches, the problem-based learning approach (PBL) has gained momentum. PBL traces its origins to the progressive evolution of medical education. In the 1970s, a team at McMaster University in Canada noted a distinction in learning conditions between medical students in the classroom and practicing physicians in the examination room. Physicians refine their expertise by navigating situations where patients pose inquiries, favoring their evolution and the cultivation of novel cognitive frameworks. Conversely, students assimilate established facts and cultivate proficiency in providing accurate responses to inquiries. However, the ability to ask questions plays a central role in the cognitive development, as the application of knowledge leads to its consolidation and real academic achievement (Gallagher 1997).

PBL is acclaimed as an innovative educational paradigm, diverging from conventional methods and thereby enhancing a myriad of skills (Rummler 2012). Perusso and Leal (2021) conducted a study in workplace education and found that traditional methods focus on presenting and explaining established knowledge and solutions and typically involve the dissemination of information by the instructor, while PBL replaces those well-defined structures with ill-defined problems. Hence, multiple solution paths are given and uncertainty about necessary concepts, rules and principles predominates (Perusso and Leal 2021).

The utilization of PBL transforms the learning process into a discovery-oriented approach, thereby drawing parallels to the resolution of real-world challenges encountered, for

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

instance, by business managers (Perusso and Leal 2021). Consequently, PBL fosters self-directed learning, integrative thinking, and collaborative problem-solving skills among students (Perusso and Leal 2021). In juxtaposing various advantages, Perusso and Leal (2021) incorporate critical perspectives in their study evaluation. Notably, they contend that despite the analogies drawn with the professional realm, a deficiency in interaction with the actual work environment diminishes the approach's realism. Additionally, the teacher assumes a less conventional role, serving more as a facilitator than a traditional guide, potentially leading to a dearth of guidance for the students. Moreover, they raise concerns about the time-intensive nature of PBL and the unconventional, hence challenging, assessment methods.

However, it is worth noting that other studies counterbalance these criticisms, emphasizing the substantial benefits of PBL. In an exploration of how PBL serves as an effective tool in academic settings, researchers, such as Fassbender et al. (2022), underscore the pivotal role of the facilitator. PBL as a learner-centered approach not only fosters integration and interaction among students but also empowers them to take ownership of their learning. The intrinsic way of working promotes collaborative learning (Phungsuk et.al., 2017) and the co-construction of knowledge among students, and thus leads to a development of social competencies (Fassbender et.al. 2022). Despite the time-consuming aspect of PBL, students gain the opportunity to delve into content for extended durations, fostering profound understanding, critical thinking, independent problem-solving skills, and enduring retention of knowledge (Fassbender et al., 2022). The findings resonate with the assessment conducted by Carlisle and Ibbotson (2005) regarding the efficacy of PBL learning within a postgraduate research methods module.

Beyond these advantages, students affirmed that PBL, with its participatory nature and incorporation of real-life scenarios, rendered the subject matter inherently more engaging and interesting (Carlisle and Ibbotson 2005). Additional forms of innovative approaches encompass project-oriented learning (POL) and research-based learning (RBL). Fundamentally, these approaches do not deviate significantly from the PBL model; rather, they are better characterized as augmentations to it. For instance, while PBL and POL share various traits, they diverge primarily through the enhanced competencies introduced by PBL. In this context, the applied methodology tends to be more authentically rooted than in "artificial" PBL scenarios. The projects are not mere simulations but constitute an approach to reality, establishing a situated framework within the project context (Rummler 2016). Broadening this framework by incorporating concrete theory and empiricism transforms it into RBL. In this method, students, in addition to the aforementioned criteria, also formulate a research approach and pose a research question (Hoffmann 2016, Rummler 2016).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

2. Methodology

For the further development of PBL and related approaches in university education, we analyze the project studies at Bochum University of Applied Sciences. The goal of these project studies is to enable students to learn in a new way and maximize the output for the research projects. To this end, it is necessary to have an overview of the implementation of the projects as PBL projects. For this purpose, we chose an evaluation approach in which the relevant stakeholder groups (students and lecturers) were involved.

A written survey was used as a quantitative research method to collect data from the stakeholder groups. The survey was conducted at the end of one semester and will be repeated from then. It was conducted electronically as between 2 January 2024 and 17 January 2024 using the web-based survey software evasys. The Course Experience Questionnaire (CEQ) we used as a basis for the development of the survey to record the quality of training and the PBLEQ Evaluation Questionnaire (PBLEQ) to record the learning approach. The CEQ is an elaboration of teaching quality at universities and was developed as an instrument for evaluating teaching in various categories (1) Good teaching, (2) Clear objectives and standards, (3) Appropriate assessment, (4) Measured workload, (5) General skills (Ramsden 1992). The Course Experience Questionnaire was developed in a cumulative process to survey Australian graduates and established itself as an indicator for good teaching (Müller, Tichler 2007). The PBLEQ serves as an instrument for recording student assessment. It is used to evaluate the perceived learning success, the change in the learning process and the motivation and acceptance of the students in relation to this teaching approach (Müller, Eberle 2009).

The survey was then further developed to include specific questions on the research projects from which the questions for the students were developed. The questionnaire for the students is structured in such a way that a common basic understanding of the learning approaches is asked first. This is followed by questions on individual skills and competencies learned as closed questions. These are the competencies that must be present for the PBL approach to be successful. These are compared with the individual's own expectations regarding the task and tutorial support in open questions. The questionnaire for the lecturers is structured simultaneously and initially asks about the skills promoted, the experience and the approach to the project as well as an assessment of the learning success, so that the assessment of the students and the lecturers can be compared in the evaluation.

3. Results

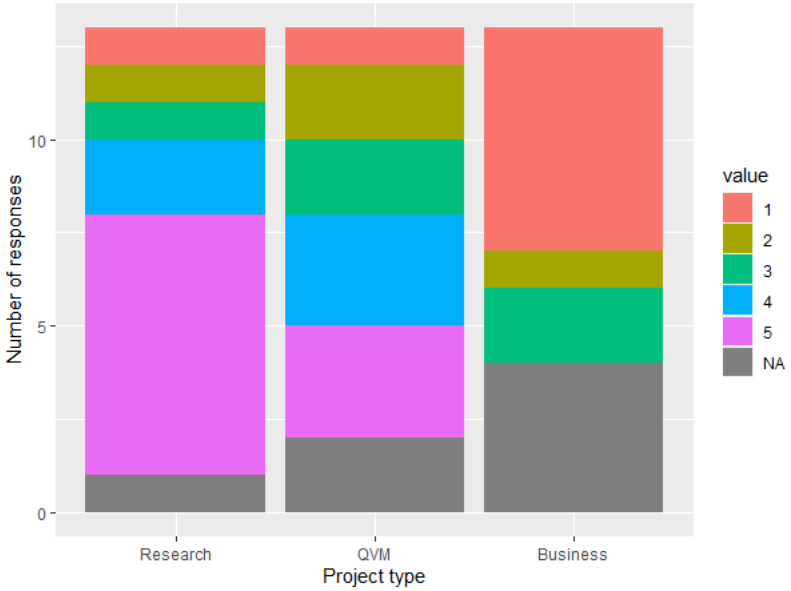
We start by providing some details about the participants in our surveys. Overall, 60 students and 13 lecturers completed the questionnaire. The majority of lecturers (n=8) indicated that

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

they use PBL in their courses, while the other options of POL and RBL) are applied three times and two times, respectively.

The lecturers in the sample tend to relate the content of their courses to their own research projects (Fig. 1). Specifically, nine of the 12 responding lecturers indicate on a five-point Likert scale that the course's content relates "rather" or "very much" to the content of the research projects. In contrast, for contracted research projects, the majority of lecturers (n=6) reported a "very low" relationship.

Figure 1: Relationship between course and projects, "Research" represents third-party funded projects with an academic purpose, "QVM" projects have the purpose of improving teaching, "Business" stands for projekts from contract research

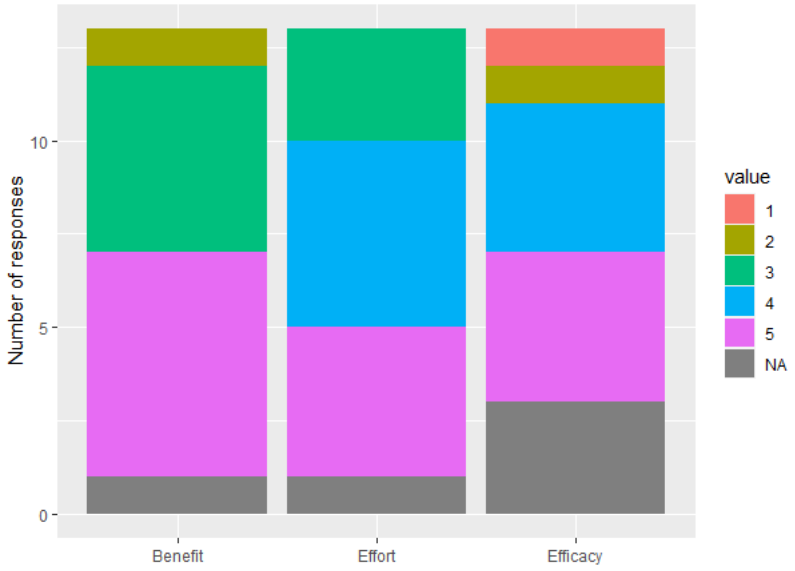


Source: Own elaboration

About half (n=6) of the surveyed lecturers report "very high" benefits from conducting the project study (Fig. 2). Moreover, roughly the same number of lecturers (n=5) estimate that the benefit is "medium. However, the majority also indicates high or rather high effort that they invest into the project study. To be precise, nine of the 12 responding lecturers report "rather high" or "very high" effort. Nevertheless, overall, almost all lecturers conclude that involving students in the research projects is effective in generating research results. Only two lecturers report that in this regard, the research project is not effective. Moreover, three lecturers report that the project study has led to stimuli for their future research. Overall, three lecturers stated that the students' work has resulted in scientific outcome, namely in seven peer-reviewed conference contributions and three peer-reviewed journal articles.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Figure 2:Benefit, effort and efficacy of project studies



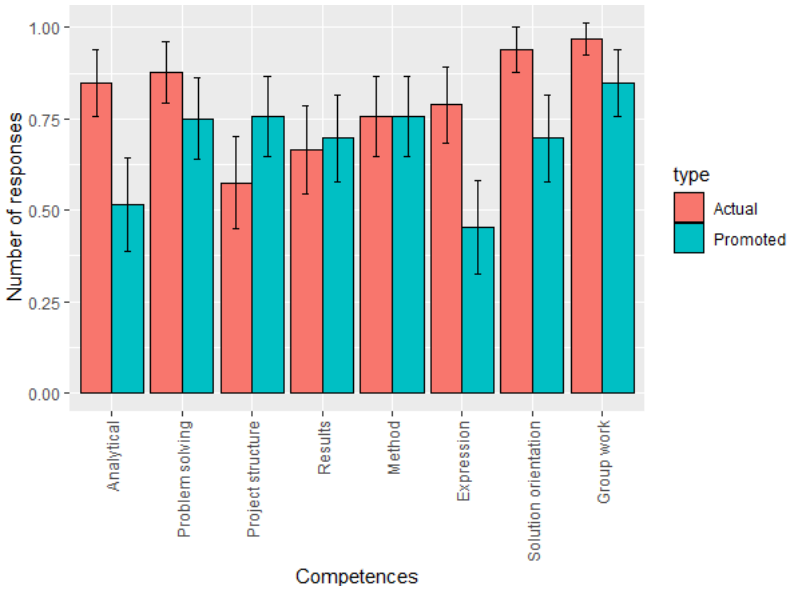
Source: Own elaboration

The student sample is almost equally split between bachelor (n=26) and master (n=32) students. Moreover, 33 of the responding students took part in a project study in the semester the interview took place and 25 students in the previous semester. More than 40% of the students stated that they took part in a course that applies the PBL concept. A slightly lower share of 35% reported taking part in a POL approach. Only a minority of 13% took part in a RBL course.

Students who are participating in a project study during the semester the survey took place were asked which competences they bring along, while students who participated in a previous semester were asked about which competences were promoted during the project study. Answers to both questions were elicited on a five-point Likert scale but for the sake of clarity we report them as binary variables. Fig. 3 contrasts the answers, covering all competences. It bears noting that more than 75% of students believe they bring along analytical competences, but only half the students feel these get actually promoted in the project study. A t-test on the equality of means suggests that this difference is statistically significant at the 5% level. Similarly, three quarters of students believe they bring along competences in expression, but they do not feel that these get promoted in the project study. For all other competences, the differences in perceptions are rather small.

2024, Editorial Universitat Politècnica de València BY-NC-SA

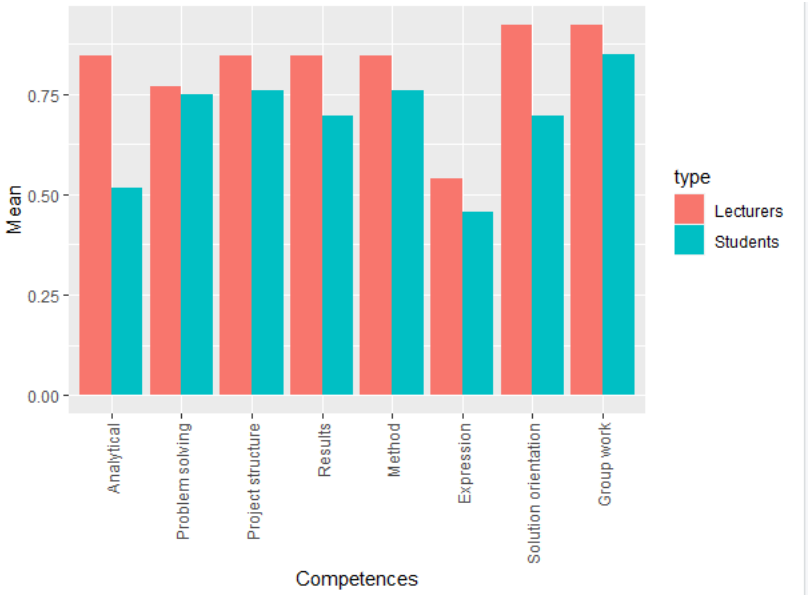
Figure 3: Actual and promoted competences



Source: Own elaboration

In the survey, we also asked the lecturers to estimate which competences are promoted in their project study. Because of the small number of responses, we omit the error bars. Compared to the students, the lecturers report a larger promotion of all competences (Fig. 4). The differences are particularly large regarding analytical competences and solution orientation. One reason for the divergence might be that students feel the effort needed to participate in the project study was low. Almost 70% of the responding students report that the effort was "very" or "rather low".

Figure 4: Promoted competences estimated by students and professors



Source: Own elaboration

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Nevertheless, when asking about the learning success, it seems lecturers and students agree, even though the questions were asked slightly different. On a scale from 0 to 10, lecturers were asked how they think the learning success of the applied method (PBL, POL or RBL) relates to other methods. All of them report a value between 8 and 10. In turn, students were asked whether they would recommend the project study to other students because of their learning success on a four-point scale. Roughly two thirds of the students indicated that they would recommend the project study.

4. Conclusion

In conclusion, this study highlights the efficacy and challenges of PBL in higher education, especially in sustainability programs. It emphasizes the positive perception of both students and professors towards PBL, citing its role in enhancing critical competencies like analytical skills and problem-solving. Despite concerns about its time intensity, PBL proves effective in fostering deep understanding and collaboration. Challenges such as the need for clearer student guidance and faculty time investment underscore the importance of ongoing support in PBL implementation. Nonetheless, PBL remains a valuable educational tool for enhancing student engagement and addressing real-world sustainability challenges. Further research and collaboration are needed to refine and expand PBL's use in higher education, ensuring students are equipped to contribute to sustainable development. Despite valuable insights, the study's limitations due to a small survey sample suggest the need for broader research across diverse university settings to fully understand PBL's impact and enhance sustainability education.

Acknowledgements

We gratefully acknowledge the support of the European Commission under the Erasmus+ funding program, grant number 101056147, for making this research possible.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Carlisle, C., Ibbotson, T. (2005). Introducing problem-based learning into research methods teaching: Student facilitator evaluation. Nurse Education Today 25 (7), 527-541. https://doi.org/10.1016/j.nedt.2005.05.005

Fassbender, U., Papenbrock, J., Pilz, M. (2022). Teaching entrepreneurship to life-science students through Problem Based Learning. *The International Journal of Management Education 20 (2022) 100685*. https://doi.org/10.1016/j.ijme.2022.100685

 BY-NC-SA

Gallagher, S. A. (1997). Problem-Based Learning: Where Did it Come from, What Does it Do, and Where is it Going? Journal for the Education of the Gifted, 20(4), 332-362. https://doi.org/10.1177/016235329702000402

Hoffmann, S.G., Kiehne, B. (2016). *Ideen für die Hochschullehre. Ein Methodenreader.* Universitätsverlag der TU Berlin. https://doi.org/10.14279/depositonce-4916

Perusso, A., Leal, R. (2021). The contribution of execution and workplace interaction to problem-based learning. *The International Journal of Management Education 20 (2022) 100596*. https://doi.org/10.1016/j.ijme.2021.100596

Phungsuk, R., Viriyavejakul, C., Ratanaolarn, T. (2017). Development of a problem-based learning model via a virtual learning environment. *Kasetsart Journal of Social Sciences 38*, 297-306. https://doi:10.1016/J.KJSS.2017.01.001

Rummler, M. (Hrsg.) (2012). *Innovative Lehrformen: Projektarbeit in der Hochschule. Projektbasiertes und problemorientiertes Lehren und Lernen.* Weinheim: Beltz.

Steiner, G., Posch, A. (2006). Higher Education for Sustainability by Means of Transdisciplinary Case Studies: an Innovative Approach for Solving Complex, Real-World Problems. *Journal of Cleaner Production 14*, 877-890. https://doi.org/10.1016/j.jclepro.2005.11.054

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Sustainable Education for Business Leaders: Integrating Corporate Social Responsibility (CSR) and Environmental, Social, and Corporate Governance (ESG) in MBA Programs – A Vietnamese Perspective

Lorena Mathien[a]

[a]Business Department, State University of New York at Buffalo State, USA

Abstract

Sustainable education is a necessary component in developing the next generation of business leaders providing them knowledge and values necessary to navigate the complex challenges of sustainable business practices. This paper explains the crucial role of sustainable education in MBA programs, emphasizing its implications for societal well-being, economic viability, and environmental stewardship, and applies it to the Vietnamese context.

Recent literature highlights the importance of sustainability but none that apply it to a particular cultural context. The focus on integrating sustainable education within the Vietnamese context aligns with the country's aspirations for sustainable development and responsible business practices. This paper aims to explore and contribute to this critical intersection of education, business, and sustainability.

We use a case study taught in an accelerated EMBA classroom using a competency-based learning (CBL) model. By integrating CBL into sustainable education, MBA programs can ensure that graduates not only possess theoretical knowledge but also have the practical skills needed to drive sustainable practices in the business world. This approach emphasizes the importance of continuous learning and adaptability in future business leaders.

Keywords: Corporate Social Responsibility; CSR; Environmental Social Governance; ESG; Ethics; Sustainability.

How to cite: Mathien, L. (2024) Sustainable Education for Business Leaders: Integrating Corporate Social Responsibility (CSR) and Environmental, Social, and Corporate Governance (ESG) in MBA Programs – A Vietnamese Perspective. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 970-978. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

Sustainable education is critical in shaping the next generation of business leaders who are not only adept in traditional business practices but are also equipped with the knowledge and values necessary to navigate the complex challenges of sustainability. This paper explains the crucial role of sustainable education in MBA programs, emphasizing its implications for societal well-being, economic viability, and environmental stewardship, and applies it to the Vietnamese context.

Businesses today operate in an environment characterized by increasing interconnectedness, heightened environmental awareness, and a growing demand for social responsibility. In this context, MBA programs play a pivotal role in preparing leaders who can balance economic success with ethical decision-making and environmental stewardship. Sustainable education in MBA programs foster holistic leadership development by integrating environmental, social, and economic considerations, equipping graduates to lead organizations with an understanding of the interconnectedness of these dimensions. Stakeholders, including consumers, investors, and regulatory bodies, increasingly expect businesses to operate responsibly. MBA programs that integrate sustainability ensure that graduates are well-prepared to meet these expectations, enhancing the reputation and trustworthiness of businesses. As businesses operate in an interconnected world, graduates need to understand and address global sustainability challenges, making them versatile and capable of navigating diverse international business environments.

Integrating sustainable education helps MBA graduates recognize and mitigate risks associated with environmental, social, and governance (ESG) factors. Sustainable education also fosters a culture of innovation and entrepreneurship, and MBA graduates, armed with knowledge about corporate social responsibility (CSR) and ESG, are better positioned to drive innovation within organizations, gaining a competitive advantage in the market.

1.1 Focus on Integrating CSR and Sustainable Energy in the Vietnamese Context

Vietnam, with its dynamic economic growth and increasing global integration, provides a compelling context for the integration of CSR and ESG. Vietnam's rapid growth is coupled with environmental challenges, and thus, integrating sustainable education addresses the need to balance economic development with environmental sustainability. Many Vietnamese companies are recognizing the importance of CSR as a fundamental part of their business strategy and the integration of CSR in MBA programs aligns with the practical needs of the local business landscape. Vietnam is undergoing an energy transition to meet the rising demand for power sustainably and integrating sustainable energy education aligns with the country's commitment to achieving the United Nations' Sustainable Development Goals (SDGs).

BY-NC-SA 2024, Editorial Universitat Politècnica de València

As global scrutiny on corporate practices increases, Vietnamese companies are seeking recognition for sustainable initiatives. MBA programs focused on CSR and ESG prepare graduates to contribute to these initiatives, fostering collaboration between academia and industry. By taking the lead in integrating CSR and ESG education, Vietnamese MBA programs can establish themselves as educational leaders in Southeast Asia, attracting students and faculty interested in sustainable business practices.

In summary, the significance of sustainable education in MBA programs lies in its ability to mold socially responsible, globally aware, and environmentally conscious business leaders. The focus on integrating CSR and ESG within the Vietnamese context is not only timely but also aligns with the country's aspirations for sustainable development and responsible business practices. This paper aims to explore and contribute to this critical intersection of education, business, and sustainability.

2. Literature Review

Seminal authors of corporate responsibility, such as Frederick (1960), McGuire (1963), and Carroll (1999), stated that organizations should assume responsibilities to society beyond their legal and economic obligations and must base their actions on ethical management, considering the quality of life of employees, the relationship with stakeholders, and the reduction of negative impacts of operational activities on the community and the environment.

In 2015, the United Nations General Assembly launched the current 17 SDGs with a 2030 agenda of a joint effort by countries, companies, institutions, and society focused on eradicating poverty, fighting inequality and injustice, and protecting the planet. With the recent pandemic and climate crisis, many investors and policy makers worldwide see a need to accelerate investment in CSR and ESG, the models by which companies make a concerted effort to operate in ways that enhance rather than degrade society and the environment. Considering this trend, public and private organizations are also in search of sustainability experts (Deitche, 2010; Hesselbarth and Schaltegger, 2014; Kiron et al., 2012).

Responding to companies' needs, top universities now offer ESG-focused MBAs, individual classes on CSR topics, or have integrated CSR and ESG issues into their curricula (Brammer et al., 2019; Schroeder-Saulnier, 2007; Wright and Bennett, 2011), teaching sustainability, ethical and moral values, human rights, and transparency (Esfijani and Chang, 2012) in core and elective courses, especially at the MBA level (Brammer et al., 2012; Christensen et al., 2007; Schroeder-Saulnier, 2007; Wright and Bennet, 2011). One of three pedagogical approaches is typically applied, integration into an existing course, creation of a new course, or integration into disciplines and programs (Pizzutilo and Venezia, 2021; Rusinko, 2010; Thomas, 2004), using various teaching methodologies, including case studies, service

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

learning, problem-based learning, and experiential learning (Figueiró and Raufflet, 2015; Gatti, et al., 2019; Schimperna et al., 2022). Case studies allow students to actively engage in discussions and apply concrete management techniques to real-world problems (Mesny, 2013; Reficco et al., 2019). Service-learning projects provide hands-on student participation in community projects (Brundiers et al., 2010). In problem-based learning, students address the underlying issues of a real problem and find a viable solution via collaboration and information sharing (García-Rosell, 2013; Gatti et al., 2019). Experiential learning relies on learning through action (Shrivatava, 2010), typically using simulations (Doyle and Brown, 2000).

3. Competency-Based Learning and Skill Assessment

Competency-based learning (CBL) is a student-centric educational approach that focuses on the mastery of specific skills and knowledge rather than the traditional time-based model. Applying CBL in the context of CSR and ESG enhances the effectiveness of the learning experience, ensuring that graduates are well-equipped with the practical skills and knowledge required for responsible business leadership.

The first step is identification of the key competencies relevant to CSR and ESG within the context of business leadership. These may include ethical decision-making, environmental stewardship, social impact assessment, sustainable business model development, and stakeholder engagement. Next, competencies are mapped to specific learning outcomes.

Then, projects and assignments are developed that require students to apply their competencies to solve actual business challenges faced by organizations. The flexibility of CBL can allow students to create personalized learning paths, accommodating varying levels of prior knowledge and the focus on competencies where improvement is most needed.

Finally, implementation of both formative and summative assessments is used to evaluate the progress and mastery of competencies. Formative assessments, such as ongoing assignments and discussions, provide continuous feedback, while summative assessments, such as capstone projects, evaluate overall competency attainment. Clear and detailed rubrics that articulate the specific criteria for mastery are aligned with each competency. Regular feedback and reflection allow students to understand their strengths and areas for improvement, fostering a culture of continuous learning and improvement.

Best practices in CBL leverage educational technology such as virtual labs, simulations, and interactive e-learning. Some also award competency-based credentials or badges upon the mastery of specific competencies as tangible proof of a student's proficiency. Faculty should also encourage collaboration and peer learning such as group projects, case studies, and discussion. In addition, adaptive learning platforms that tailor educational content based on

BY-NC-SA 2024, Editorial Universitat Politècnica de València

individual progress can identify areas where students may need additional support to master specific competencies.

4. Teaching and Learning in a Vietnamese EMBA Class

The CBL model was employed in a nine-day EMBA CSR class where all students were employed in executive positions with no understanding of CSR or ESG. Competencies were mapped to student learning outcomes (table 1).

Table 1 – Core Competencies and Student Learning Outcomes

Core Competencies	Student Learning Outcomes (Graduates will …)
Ethical Decision-Making and Leadership	demonstrate the ability to assess ethical dilemmas, make informed decisions, and exhibit ethical leadership within organizational contexts.
Stakeholder Engagement and Relationship Management	identify, analyze, and engage with diverse stakeholders, incorporating their perspectives into decision-making processes.
Strategic Integration of CSR	integrate sustainability considerations into business strategies, ensuring alignment with environmental, social, and economic factors to create long-term value.
Social and Environmental Impact Assessment	evaluate the social and environmental impact of business activities, measure outcomes, and assess contributions to societal well-being.
Transparency, Reporting, and Compliance	communicate CSR efforts transparently through reporting, ensuring stakeholders are informed, and adhere to relevant CSR regulations and compliance requirements.
Cross-Functional Collaboration and Community Relations	collaborate cross-functionally, fostering positive relationships with local communities, understanding their needs, and developing strategies for community development.
Continuous Learning, Adaptability, and Global Perspective	exhibit a commitment to continuous learning, staying informed about global CSR trends, and adapting strategies to navigate CSR challenges in a globalized business environment.

Source: Mathien (2024)

Competencies must align with industry standards and expectations. Collaboration with industry experts and professionals validate the relevance and applicability of the identified competencies in the context of CSR and ESG. The adoption of CSR and ESG practices can vary across countries due to differences in cultural, economic, regulatory, and social contexts. When comparing Vietnam and the United States, several factors contribute to the distinct approaches and challenges in the adoption of CSR including cultural differences, economic development, regulatory environment, social expectations, government control, stakeholder influence, education and awareness, and environmental concerns.

Activities and projects were then assigned that applied the core competencies and related them to the Vietnamese context. Students had a choice from various ethical dilemmas presented in mini case studies and would debate their solutions to the various dilemmas in class. Students also developed a stakeholder engagement plan for their company, demonstrating understanding of the importance of engaging various stakeholders in

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

sustainable initiatives. Students analysed case studies, identifying key issues, proposing ethical solutions, and assessing the potential social and environmental impacts of different courses of action. The class was then divided into groups with each group taking on different roles within a business context and engaged in decision-making processes related to sustainability. In teams, students chose one organization and created a comprehensive sustainability report, including an analysis of the organization's current sustainability practices, recommendations for improvement, and a strategic plan for future CSR or ESG initiatives. Finally, each student wrote an individual paper outlining the development of CSR and ESG in Vietnam, highlighting the challenges and differences of implementing these initiatives in Vietnam compared to the western world.

Given a full-semester course or a program, students could develop a stakeholder engagement plan for a company or project, demonstrating their understanding of the importance of engaging various stakeholders in CSR and ESG initiatives. Interactive workshops where students lead discussions or activities related to CSR and ESG topics would allow them to facilitate discussions, engage peers, and communicate complex sustainability concepts. Simulation exercises could replicate CSR and ESG decision-making scenarios via online platforms or in-class simulations where students make strategic decisions considering ethical, social, and environmental factors. Opportunities for students to interview industry experts would enable them to create quality questions, increase the depth of their understanding and their ability to synthesize insights from these interviews into meaningful reflections. Students could also build a portfolio showcasing their work, including project outcomes, research papers, and reflections, providing a holistic view of their development in CSR and ESG.

These methodologies not only assess students' knowledge of CSR and sustainable energy concepts but also evaluate their practical application of these principles in various contexts. Combining a mix of assessment strategies ensures a comprehensive evaluation of learning outcomes in the dynamic field of CSR and sustainable energy.

4.1 Assessment of CBL

There are various tools that may be used to assess the impact of CBL on the acquired skills, including pre and post assessment scores, rubric-based assessment, self-assessment surveys, peer evaluations, performance on real world problems, employer feedback, retention ratios, graduation and employment rates, and qualitative feedback. We used rubric-based assessment with detailed rubrics for each competency or skill. Data was collected on how students performed against these rubrics throughout the course. Rubrics provide clear criteria for evaluating student performance and can offer into specific areas of strengths and weaknesses.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Performance on real world projects was also assessed by collecting data on student performance in these activities. These demonstrate how well students can apply their skills and knowledge in practical contexts.

In addition, qualitative feedback was obtained via interviews and surveys. Students were questioned about their experience with the CBL approach, including what they found most valuable and suggestions for improvement.

By collecting and analyzing data from various sources, a comprehensive understanding of the impact of skills assessed through CBL can be built. The data can aid in demonstrating the effectiveness of the approach and to inform future curricular development efforts.

5. Conclusion

The need for ethical standards and sustainability management experts has greatly increased (Burga et al., 2017; Hesselbarth and Schaltegger, 2014). Universities have adapted and must continue to adapt their curricula to educate responsible leaders and managers, allowing for a positive attitude toward social responsibility, improving ethical decisions for societies, and positively affecting business performance.

By integrating competency-based learning into CSR and ESG education, MBA programs can ensure that graduates not only possess theoretical knowledge but also have the practical skills needed to drive sustainable practices in the business world. This approach aligns with the dynamic and evolving nature of CSR and ESG, emphasizing the importance of continuous learning and adaptability in future business leaders.

Acknowledgements

No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Brammer, S., Powell, A., & Millington, A. (2012). Embedding sustainability in business schools: The state of the art in teaching and learning, research, and operations. *ICCSR Research Paper Series,* 60, 1-27.

Brundiers, K., Wiek, A., & Redmand, C. L. (2010). Real-world learning opportunities in sustainability: From classroom into the real world. *International Journal of Sustainability in Higher Education*, 11, 308-324.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Burga, R. Leblanc, J., & Rezania, D. (2017). Analysing the effects of teaching approach on engagement, satisfaction, and future time perspective among students in a course on CSR. *The International Journal of Management Education*. 15, 306-317.

Carroll, A. B. (1999). Corporate social responsibility: evolution of a definitional construct. Business & Society, 38(3), 268-295.

Christensen, L. J., Peirce, E., Hartman, L. P., Hoffman, W. M., & Carrier, J. (2007) Ethics, CSR, and sustainability education in the Financial Times top 50 global business schools: Baseline data and future research directions. *Journal of Business Ethics*, 73, 347-368.

Deitche, S. M. (2010) *Green Collar Jobs: Environmental Careers for the 21st Century.* Santa Barbara: ABC-CLIO.

Doyle, D. & Brown, F.W. (2000) Using a business simulation to teach applied skills – the benefits and challenges of using student teams from multiple countries. *Journal of European Industrial Training,* 24, 330-336.

Esfijani, A. & Chang, E. (2012) Metrics development for measuring virtual university social responsibility. Paper presented at 2012 IEEE 12th International Conference on Advanced Learning Technologies, Rome, Italy, July 4-6, 724-725.

Figueiró, P. S. & Raufflet, E. (2015) Sustainability on higher education: A systematic review with focus on management education. *Journal of Cleaner Production,* 106, 22-30.

Frederick, W. C. (1960). The growing concern over business responsibility. California Management Review, 2(4), 54-61.

García-Rosell, J. C. (2013) Struggles over corporate social responsibility meaning in teaching practices: The case of hybrid problem-based learning. *Management Learning,* 44, 537-555.

Gatti, L., Ulrich, M., & Seele, P. (2019) Education for sustainable development through business simulation games: An exploratory study of sustainability gamification and its effects of students' learning outcomes. *Journal of Cleaner Production,* 207, 667-678.

Hesselbarth, C. & Schaltegger, S. (2014) Educating change agents for sustainability-learnings from the first sustainability management master of business administration. *Journal of Cleaner Production,* 62, 24-36.

Irigaray, H. A. R., & Stocker, F. (2022). ESG: new concept for old problems. Cadernos EBAPE.BR, 20(4), 1–4.

Kiron, D., Kruschwitz, N., Haanaes, K., & von Streng Velken, I. (2012) Sustainability nears a tipping point. *MIT Sloan Management Review*, 53, 69-74.

McGuire, J. W. (1963). Business and society. Technology and Culture, 5(3), 478-480.

Messny, A. (2013) Taking stock of the century-long utilization of the case method in management education. *Canadian Journal of Administrative Sciences,* 30, 56-66.

Pizzutilo, F. & Venezia, E. (2021) On the maturity of social responsibility and sustainability integration in higher education institutions: Descriptive criteria and conceptual framework. *The International Journal of Management Education,* 19, 1-15.

Reficco, E., Jaén, M. H., & Trujillo, C. (2019) Beyond knowledge: A study of Latin American business schools' efforts to deliver a value-based education. *Journal of Business Ethics,* 156, 857-874.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Rusinko, C. A. (2010) Integrating sustainability in higher education: A generic matrix. *International Journal of Sustainability in Higher Education*, 11, 250-259.

Schimperna, F., Nappo, F., & Collaretti, F. (2022). Universities and CSR teaching: New challenges and trends. Administrative Sciences, 12(2), 1–12.

Schroeder-Saulnier, D. (2007) "Both/and" thinking in organizational leadership: A grounded theory study. Webster University, 171.

Shrivastava, P. (2010) Pedagogy of passion for sustainability. *Academy of Management Learning and Education,* 9, 443-455.

Thomas, I. (2004) Sustainability in tertiary curricula: What is stopping it happening? *International Journal of Sustainability in Higher Education,* 5, 33-47.

Wright, N. S. & Bennett, H. (2011) Business ethics, CSR, sustainability, and the MBA. *Journal of Management and Organization,* 17, 641-655.

2024, Editorial Universitat Politècnica de València BY-NC-SA

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Engaging students in Circular Design: teaching experiences with (future) architects and designers

Elena Montacchini, Silvia Tedesco and Nicolò Di Prima[a]

[a]Department of Architecture and Design, Politecnico di Torino, Italy

Abstract

In recent years, an increasing number of Architecture and Design Schools are investing in new teaching programs on sustainability and circular economy, considering crucial the training of new professional figures with wide-ranging skills. The paper reports the outcomes of four-year teaching experiences on the topic of circular design with (future) architects and designers, developed as part of the course Designing and Developing the Circular Economy, conducted at the Politecnico di Torino in Italy. The activities that characterize the training course focus on interdisciplinary teaching and learning experiences such as confrontation, learning-by-doing and hands-on activities with a systemic approach. These activities refer to: testimonies of actors working in the social, business and research spheres; "circular" readings derived from the international scientific debate; design sprint and self-construction workshops based on the principles of Reuse, Repurpose, Upcycling, Disassembly; and development of circular economy scenarios in real contexts. These experiences prepare the students to become professionals aware of the challenges of the circular economy, able to reflect critically on the challenges and difficulties relative to the theme, to experience the transformation of matter from waste to resource, to use with confidence tools to activate networks and circular economies at the local scale.

Keywords: circular design; higher education; learning-by-doing.

How to cite: Montacchini, E.; Tedesco, S; and Di Prima,D. (2024) Engaging students in Circular Design: teaching experiences with (future) architects and designers. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 979-987. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

In recent years, an increasing number of Architecture and Design Schools are investing in new teaching study modules and programs on sustainability and Circular Economy (CE) – such as Delft University of Technology (NL), Aalto University School of Arts, Design and Architecture (Helsinki, FI), Yale School of Architecture (New Haven, USA) and others - considering crucial the training of new professional figures with wide-ranging skills.

The transition to a circular economy produces new challenges for architects and designers, who need to acquire specific skills and competencies on more effective use of resources by closing resource loops and facing complex systems involving different stakeholders (Sumter et al., 2020).

A nascent body of literature documents different higher educational approaches: design studios and workshops (Ryńska, 2020), simulation and serious games (De la Torre et al., 2021), design-teaching activities in the context of financed research project (Wandl et al., 2019).

This paper aims to contribute to the debate on teaching circular design by describing a four-year experience of educational experiments with (future) architects and designers developed as part of the course Designing and Developing the Circular Economy at the Politecnico di Torino in northern Italy.

2. Circular Design educational experiments: methodology and results

The interdisciplinary course presented below was introduced in 2020 at the Politecnico di Torino as an optional module. It involves students with different educational backgrounds from master's degree courses in Architecture and in Design (between 50 and 80 students per accedemic year), and stakeholders from outside academia.

The course aims to train new professionals with transversal skills that may prefigure circular solutions, steer new processes, connect networks of social and economic actors, so that the waste of one can become a resource for the other. The heterogeneity of students, actors and local realities involved are added values for the learning process.

The activities that characterize the semester-long training are focused on interdisciplinary teaching (between architecture and design) and learning experiences that make confrontation, learning-by-doing and hands-on activities, the systemic vision their strengths. These activities refer to: testimonies of actors working in the social, business and research fields; "circular" readings derived from the international scientific debate; design sprint and self-construction workshops based on the principles of Reuse, Repurpose, Upcycling, Disassembly; and development of circularity scenarios in real contexts.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

The course started in conjunction with the Covid-19 pandemic and in the first two years was conducted entirely online. During this period, design sprint and self-construction activities were carried out in collaboration with the Food Design Lab of the Polytechnic University of Turin. We chose to use food as a waste material on which to experiment and household equipment as appropriate technologies. Inspections of the realities with which we developed the circular scenarios were carried out online through photos and video stories (Montacchini, Tedesco, Di Prima,2021).

2.1 Visions of circular economy

It is not straightforward to confront the topic of CE, defined in the international scholarly literature as an "umbrella-concept" that includes a very broad set of meanings and visions (Kirchherr et al., 2017).

To stimulate and support architecture and design students to build a critical approach on the topic and to approach its different economic, environmental, and social dimensions, it is required to activate debate and confrontation to question different approaches (Friant et al., 2020). In the context of the course, we tried to present and answer the various questions that belong to the EC discourses through discussions with actors and researchers active in the world of the CE and through "circular readings" selected from the international scientific literature.

In particular, the methodology adopted included discussion and interaction with the territory, the experience and visions of very diversified actors invited to answer our questions with an "open" classroom logic. Discussion and debate were also fuelled by the arguments stimulated by reading the selected articles.

For example, new roles and emerging professions for architects and designers have been debated through a series of articles (Dokter et al., 2021; Benachio et al., 2020) and through testimonies of organizations that have already incorporated the principles of circular design in developing products, services, and new materials.

These actors told us about challenges and difficulties in their work, the concrete contribution of their activities in enhancing the transition to a circular economy, the stakeholders they network with, and the tools they use. We wanted to investigate the development of the concept of "sustainability" and "circular economy," capturing their similarities, differences and possible points of convergence (Geissdoerfer, 2017). Or again, as an example, the social dimension of the circular economy was discussed (Hobson and Lynch, 2016).

Testimonials and circular readings helped students develop a multifaceted view of the circular economy, allowed them to bring out strengths and weaknesses of the different approaches,

BY-NC-SA 2024, Editorial Universitat Politècnica de València

visions, and goals that characterize the circular economy, and enabled students to position themselves critically with respect to the complexity of the topic.

2.2 Circular design sprint and self-construction workshops

Hands-on activities have long been recognized to be of strategic importance to the learning process in Architecture Schools (Mackintosh, 2014), yet there are still not many examples that combine hands-on experimentation activities with the circular economy theme.

The learning-by-doing and hands-on activities included in the course make it possible to integrate circular economy theory with practice, with the aim of promoting students' creative and problem-solving skills regarding relevant topics such as reuse, repurpose, upcycling, and disassembly of materials and products.

These activities are structured in extemporaneous workshops of limited duration, inspired by the design sprint methodology, a Google Venture process used to solve critical issues through prototyping in a short time (Knapp et al., 2016).

In just 8 hours, students are asked to design and build objects, furniture elements or micro-architectures by being inspired by the available scrap material, which drives the project. Specifically, the work phases are as follows: harvest of available materials and technologies, first cleaning of materials, definition of the project concept, design/prototype realization, prototype revision, finishing work, and project release.

During the workshop that took place in 2022 at "Costruire Bellezza", a participatory design Laboratory for Social Inclusion and Interdisciplinary Education, the brief assigned to the students was to design and make a toy for the children living in a neighbouring social house starting with wood scraps and old furniture items or portions of them (drawers, doors, chair legs, knobs) found in the "Costruire Bellezza" workshop. Toys of various kinds such as pinball machines, chess boards, table soccer were made. The figure 1 shows a go-cart made from the seat of an old stool, a discarded coat rack, salvaged wheels and scrap wood.

Fig. 1 – Human Powered Go-kart (students a.y. 2021/2022: C. Cavanna, I. Ciminiello, G. Dilauro, E. Ferrari, R. Giachi, S. Nardi)

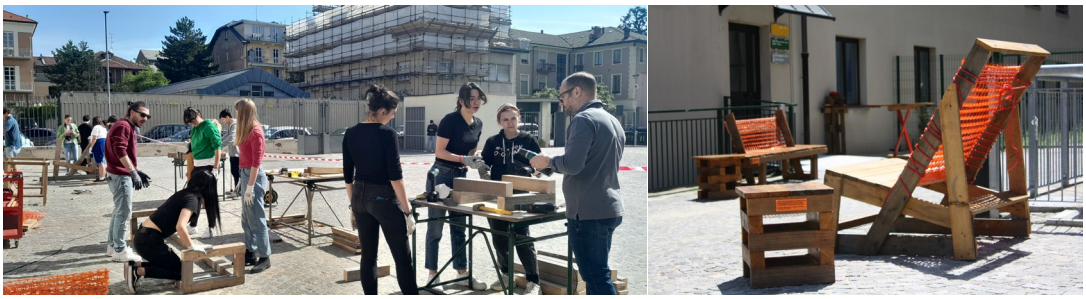


Source: authors (2022)

 BY-NC-SA

In 2023, the workshop was held at LaSTIn, the Politecnico's laboratory for the Development of Innovative Technological Systems. This time, the material came from the scraps of a construction site deposited in the courtyard of the laboratory, and the goal was to make temporary furniture for the courtyard itself. A project by the students and for the students who built tables, benches, chaise longues and stools from construction site nets, discarded pallets, old wooden boards (figure 2).

Fig. 2 – Furniture made from yard waste (students a.y. 2022/23). From left to right, processing steps and finished furniture.



Source: authors (2023)

2.3 Circular economy scenarios for the real-world

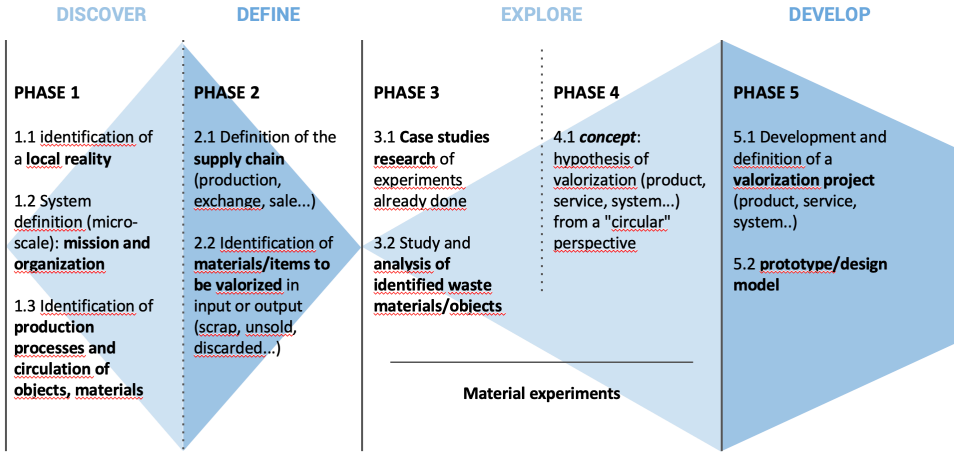
Theory and practice found a meeting point in the last activity that students conducted during the semester.

The objectives of the "Circular Economy Scenarios" activity were to identify the possibilities of activating circular economy processes within real local organizations and contexts; explore the opportunities for the valorization of materials, products, and waste within "linear" structure and supply chains; and develop a "circular" project proposal that takes into account the specificities of the chosen context from a social, cultural, technological, economic and environmental point of view.

The activities were divided into 5 phases based on the Double Diamond approach proposed by Design Council Uk as shown in figure 3.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Fig. 3 – Diagram of activities based on Double Diamond methodology



Source: authors (2024)

The students, divided into multidisciplinary groups, were tasked with identifying an accessible and willing to be "studied" local reality/organization that manufactures products and/or offers services. The first phase consisted of analyzing the processes of production and circulation of objects and materials in order to be able to recognize any inefficiencies and negative impacts in terms of waste production of the "linear" system supply chain. The second phase aimed to define the main waste products from which to start the circular design process.

In the third exploration and concept phase, students had to assess the potential for waste valorization and develop a project concept based on circularity logic.

The fourth phase consisted of developing a circular economy project for the reality investigated, taking into account real and concrete constraints and possibilities provided by the context and the surrounding area. During this phase, students had the opportunity to prototype the design solutions to verify the feasibility of the project (products, technologies, organizational systems...) and to verify the design proposals through an analytical, creative and experimental approach.

The entities involved were the most diverse with respect to both size and scope: from the food sector (e.g., farms), to the manufacturing sector (e.g., production of textiles, reconstituted stones), to those oriented toward social cooperation (e.g., cultural, educational and social associations).

The outputs produced were concepts, systems projects between actors, and actual prototypes made in the university's laboratories (strawberry picking baskets made from strawberry leaves, bags made from discarded advertising banners, tiles from stone scraps,...).

The concluding phase of the course included an exhibition of the works produced, which enabled students, faculty, companies and organizations 'studied' to network to check and

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

discuss together the real feasibility of the identified circularity scenarios (figure 4). This stage assesses students' ability to critically and reflectively answer questions regarding the sustainability of their project proposal and possible impacts in economic, environmental and social terms.

Fig. 4 – Exhibition of projects



Source: authors (2022)

3. Conclusions

The experiences described, developed in an interdisciplinary course at the Politecnico di Torino, are part of the debate on teaching circular design to (future) architects and designers. Thanks to the feedback from the students interviewed at the end of the courses, in these years of experience we have been able to ascertain that the integration of theoretical, practical and experiential activities are essential to be able to experience a critical and non-stereotypical view of CE. The proposed teaching model defines three different types of activities that contribute in different ways on training new professionals with wide-ranging skills.

The testimonies from actors of different sectors and the "circular readings" enable students to gain critical insight into a complex topic, grasping limitations and opportunities of the circular economy. The learning-by-doing and hands-on activities included in the course make it possible to integrate circular economy theory with practice and promote creative and problem-solving skills based on challenges concerning waste reduction and second-life possibilities of materials and products.Developing new "circular scenarios" in real-world settings enables strategic skills, such as the ability to design transitions to the circular economy and develop circular products and models.

All activities also enabled the development of interpersonal competencies such as collaboration, participation, empathetic exchange of perspectives, and teamwork abilities.

These experiences prepare the students to become professionals aware of the challenges of the circular economy, to be able to reflect critically on challenges and difficulties relative to

BY-NC-SA 2024, Editorial Universitat Politècnica de València

the topic, to experience the transformation of matter from waste to resource, to use with confidence tools to activate networks and circular economies at the local scale.

Acknowledgements

Thanks to all the students (A.Y. 2020/21, 2021/2022, 2022/2023), experts, companies, organizations (M. Cappellini – Matrec; M. Mangione – OffGrid Italia; Pier Andrea Moiso, - Triciclo Scs; S. Giorgi – Politecnico di Milano; D. Dal Palù – MatTO, Politecnico di Torino; M. D'Urzo - Politecnico di Torino) and laboratories (Food Design Lab; Costruire Bellezza - Laboratory for Social Inclusion and Interdisciplinary Education; LaSTIn - Laboratory for the Development of Innovative Technological Systems, Politecnico di Torino) involved in the Circular Design experiences. No funding has been received for the development of the research.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Benachio, G. L. F., Freitas, M. D. C. D., & Tavares, S. F. (2020). Circular economy in the construction industry: A systematic literature review. *Journal of cleaner production*, *260*, 121046.

De la Torre, R., Onggo, B. S., Corlu, C. G., Nogal, M., & Juan, A. A. (2021). The role of simulation and serious games in teaching concepts on circular economy and sustainable energy. *Energies*, 14(4), 1138.

Dokter, G., Thuvander, L., & Rahe, U. (2021). How circular is current design practice? Investigating perspectives across industrial design and architecture in the transition towards a circular economy. *Sustainable Production and Consumption*, *26*, 692-708.

Friant, M. C., Vermeulen, W. J., & Salomone, R. (2020). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling*, *161*, 104917.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. *Journal of cleaner production*, *143*, 757-768.

Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. *Futures*, *82*, 15-25.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, conservation and recycling*, *127*, 221-232.

Knapp, J., Zeratsky, J., & Kowitz, B. (2016). Sprint: How to solve big problems and test new ideas in just five days. Simon and Schuster.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Mackintosh, L. (2014). Just doing it: The role of experiential learning and integrated curricula in architectural education. *The International Journal of Pedagogy and Curriculum*, 20(3), 67-78.

Montacchini, E., Tedesco, S., & Di Prima, N. (2021). Progettare e sviluppare l'economia circolare. Un'esperienza didattica sulla trasformazione di rifiuti in nuove risorse per l'architettura e il design. Anteferma.

Ryńska, E. (2020). Design workshops and the circular economy. *Global Journal of Engineering Education*, 22(1).

Sumter, D., de Koning, J., Bakker, C., & Balkenende, R. (2020). Circular economy competencies for design. *Sustainability*, 12(4), 1561.

Wandl, A., Balz, V., Qu, L., Furlan, C., Arciniegas, G., & Hackauf, U. (2019). The circular economy concept in design education: Enhancing understanding and innovation by means of situated learning. *Urban Planning*, 4(3), 63-75.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Conference on Sustainable Energy Education – SEED 2024
Valencia, Spain, 3 - 5 July 2024

Sustainable Education in Art and Design Universities: A Teaching Case Emphasizing Materials

Ziyu Zhou[a], Anna Palm[b] and Markus Holzbach[a]

[a]Institute for Materialdesign IMD, Offenbach University of Art and Design, Germany
[b]Office for Sustainability, Offenbach University of Art and Design, Germany

Abstract

Higher Education for Sustainability is important in art and design universities, where reflective practices on Sustainable Development Goals and relevant principles are prevalent in teaching and learning. Materials, a key element in sustainable principles, receive lots of attention in art and design education, especially concerning whether the selection and processes used sufficiently reduce environmental impact. This paper presents a teaching case at an art and design university in Germany. It provides insights on how to cultivate sustainability awareness within these students and to trigger reflective, creative activities by knowledge sharing and perspective switching. This paper demonstrates a material-centred teaching approach for acquiring sustainable knowledge and skills, especially for art and design students. By presenting this case, this paper offers fresh perspectives for sustainable education in arts and design universities, as well as inspires comprehensive approaches to enhance sustainability education in higher education institutions.

Keywords: Education for Sustainable Development (ESD); Teaching Sustainability in Art and Design Universities; Art Education; Design Education; Material Design.

How to cite: Zhou, Z.; Palm, A. and Holzbach, M. (2024) Sustainable Education in Art and Design Universities: A Teaching Case Emphasizing Materials. In proceedings: Conference on Sustainable Energy Education – SEED 2024. Valencia, Spain, 3 - 5 July 2024. 988-994. https://doi.org/10.4995/SEED2024.2024.19007

BY-NC-SA 2024, Editorial Universitat Politècnica de València

1. Introduction

1.1 Sustainability in design and art education

Sustainable development has been a longstanding topic in the scope of art and design. The theoretical framework for Design for Sustainability (DfS) has been systematically evolving since the 1980s. These discussions have progressed beyond mere product innovation, extending into product-service systems and, notably, spatial and social innovation, to provide solutions on how design drives radical transformational changes (Ceschin and Gaziulusoy, 2016). From a historical view, the 'Limits to Growth' came into the public eye at the beginning of the 1970s. From these global considerations, a working group named 'Des-In' at the Hochschule für Gestaltung in Offenbach developed initial approaches to 'Recycling Design' (Gros, 1993). Nowadays, designers play a pivotal role in shaping the products, environments, and systems that influence our daily lives. In the art scope, the ecological or social responsibility expressed by artists through their works caught attention (Wall et al., 2019). The intense emotions and messages conveyed within the artwork shed light on a spectrum of inequalities in both the environment and society, presenting promising perspectives and outcomes while offering innovative approaches to address sustainability problems (Lineberry and Wiek, 2016). Competence-based teaching is required for university, which goes beyond a purely input-oriented and knowledge-based education. For Education for Sustainable Development (ESD) in higher education, the core competencies of *understanding, assessing, changing*, and *acting* are postulated as overarching learning objectives (Bellina et al., 2020). Enabling students to develop their understanding of sustainability issues and normative skills to weigh up the consequences is critical, as well as question paradigms in a visionary way and to be able to contribute competently to change processes and shape them.

1.2 Materials knowledge engaging sustainable education

Materials knowledge is critical in the context of sustainable development as a transversal aspect. In design education, materials knowledge is often about material selection based on their technical properties and sensorial attributes. In art education, materials are also regarded as crucial catalysts for inspiration, as the conceptual or expressive properties of materials engage with the intention of understanding the meanings and aesthetics of the artwork (Nimkulrat, 2010). Moreover, the environmental or socio-cultural meanings behind materials inspire artists to create works that align with principles of sustainability. For instance, in the "Architectures of Weaving" project, a more sustainable and flexible approach to addressing contemporary challenges is proposed through case studies from various perspectives in textile thinking. This project highlights the importance of considering the environmental and social-cultural implications of materials, contributing to the creation of works that adhere to sustainable principles (Sauer et al., 2022). Materials can function as a

BY-NC-SA 2024, Editorial Universitat Politècnica de València

cross-cutting theme that fosters individuals' comprehension and exploration of sustainable goals, influencing a shift in decision-making behavior. Therefore, a course open to all levels of students in the Offenbach University of Art and Design (abbreviated HfG Offenbach) on "Materials and Sustainability" is offered to deepen students' understanding of sustainable issues through the lens of materials.

1.3 An introduction of the case university "HfG Offenbach".

The HfG Offenbach is located in the state of Hesse, Germany. It upholds the traditions and methodologies of German design education and heritages the Bauhaus movement. In general, all German universities are required to include sustainable development in their strategy and program development (HRK, 2018). A special role is played by the federal state of Hesse, which explicitly requires sustainability efforts from its universities both by law and as part of its individual target agreements, and has made funds available to support them accordingly. The HfG Offenbach has not yet adopted a strategy, but is continuously working on improvements through the establishment of an office for sustainability. The pedagogical approach presented here is part of these efforts (Hesse State Government, 2022; HessHG, 2021).

2. Course Structure

The course is conducted at the Institute for Materialdesign (IMD) of the Offenbach University of Art and Design. The institute specializes in the experimental and interdisciplinary intersection of design and materialization, with a focus on the role of materials in the design process (Holzbach, 2014). Teaching and research at IMD is based on the *Designing With Designed Materials* method developed there. Contrary to many predictions, materials have not lost their importance due to the development of the digital world. Despite the advancement of digitalization, it is essential to recognize that it occurs within the context of our world – a physical world (Holzbach, 2021). This precisely highlights the increasingly central role of materials in discussions about ecology and sustainability. After all, the ever-increasing scarcity of resources and worsening environmental pollution are caused by the materialization of our designed "world of things" in the physical world. The course aims to sensitize future designers to the issues surrounding our environment by means of an appropriate curriculum.

The course's curriculum is organized into lectures and in-class seminars across three modules. The structure is designed to cultivate the core competencies of ESD in higher education: *Understanding, assessing, changing,* and *acting.* The first module addresses themes pertinent to the Anthropocene epoch, highlighting the accelerating decline of terrestrial and aquatic ecosystems and biodiversity (Butchart et al., 2010; Rockström et al., 2009) to underscore the imperative for climate change mitigation and adaptation efforts. This module emphasizes

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

the environmental footprint of materials within industrial production systems and their pervasive impact on bodies of water, air, soil, and beyond. Additionally, it explains new materials such as "Plastiglomerates", which symbolize the fossilization of the Anthropocene era (De-la-Torre et al., 2022).

The second module includes the reflective recreation and regeneration of materials by artists and designers. With the democratization of personal fabrication technology, people have gained more capabilities to design new materials or engage in artistic creations in unconventional ways (Zhou et al., 2018). Institutes and SMEs that lay on material innovation business are increasing, bringing new possibilities to the industry (D'Olivo & Karana, 2021; Rognoli et al., 2022). The third module of the course includes knowledge and methods from design and engineering, including the introduction of principles of the life cycle assessment and open-source material selection tools, such as the *Industrial Design & Engineering MATerials* database.

The course is designed to last for one semester (16 weeks), with one 90-minute session per week. It is optional for students, but they can earn three credit points by completing it. The majority of the sessions are lectures, and interspersed among them are in-class seminars that require active participation. Students are anticipated to offer feedback across diverse knowledge modules. For instance, in the second module, a participatory seminar requires students to analyze material innovation projects and assess their sustainable strategies. The ultimate course task for each participant is to propose a strategy for a sustainable future.

3. Results

The course spanned two semesters at HfG Offenbach, with numerous students participating in the lectures. For the final assignment of the course, participants were tasked with preparing a 5-minute presentation summarizing the insights they acquired from the course and proposing their sustainable strategies. The presentation was considered a crucial benchmark for evaluating the course's results and effectiveness. The assessment covers the level of professionalism of the insights gained by students during the course, specifically including: [1] understanding of knowledge related to the topic and [2] critical thinking about the proposed sustainable strategies, such as "in which way to implement this strategy, and which stakeholders will be included".

In total, fifteen students proposed initiatives for a sustainable future through their projects, providing valuable insights into the interests of art and design students in sustainability. The submitted individual assignments show diverse approaches to how art and design students reflect on sustainable issues, including [1] proposing new strategies for advocating a more sustainable lifestyle, [2] visualizing critical information to raise awareness of resource consumption issues and empower consumers, and [3] implementing unconventional

BY-NC-SA 2024, Editorial Universitat Politècnica de València

approaches to regenerate new materials and products from waste, seeking novel using scenarios to challenge our current consumption habits. For instance, Jannis Eickert conducted preliminary research on techniques for converting wasted plastic bottles into 3D printing filaments. Inspired by Reiten Cheng's "Polyformer" and "Pullstrusion", he researched possible approaches to turning plastic waste into recycled filaments. Another example from Fabian Arnold explored possibilities for extracting natural pigments from food waste and utilized them to create a calendar aligned with the seasonal availability of fresh produce. These preliminary strategies and related hands-on experimentation inspired other design projects in students' study path to further explore a specific topic spontaneously.

4. Discussions

The insights derived from this teaching practice are multifaceted. Within the realm of sustainability education at art and design universities, the result of this course indicates the reflective approach taken by students toward the pressing sustainability issues of our time: they tend to create and convey new concepts and cultures in a sensory and radical manner. They show a keen interest in decision-making processes and their impact on sustainability, and they are passionate about disseminating and practicing sustainable principles and concepts in unconventional ways. Positive feedback from students regarding the course topic "materials and sustainability" reflects the effectiveness of this material-centered teaching approach.

In recent years, in the design field, the continuously evolving knowledge and discussions in the branches of the "material design" and the "design for sustainability" inspired new approaches to reflect on current environmental impacts or social sustainable systems, such as bio-design and bio-fabrication. Consequently, the material-centered teaching approach can be enriched to integrate these emerging knowledge and methods, fostering new dialogues and practices. Given the cultural and artistic focus of the course, its approach holds promise for adaptation into strategies aimed at raising public awareness of sustainability. This could take the form of public exhibitions or participatory workshops, serving to engage the public in understanding current opportunities and challenges in sustainable development.

This discussion also presents the aspiration for materials and design to maintain one of its pivotals role in the curriculum of art and design universities, which is intertwined with crucial inquiries concerning ecology and sustainability. The motivation for sustainable design at IMD originates not only from teaching and research on the significance of materials in the design process, but also from the university's longstanding tradition. Recognizing the significance of ecology and sustainability should be an elementary component of the design process right from the start.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA

Acknowledgements

We extend our gratitude to the Institute for Materialdesign (IMD) and the Office for Sustainability at the Offenbach University of Art and Design for their instrumental role in bringing this course to reality. Special thanks to all the dedicated students who actively participated the course.

Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

References

Bellina, L.; Tegeler, M.K.; Müller-Christ, G.; Potthast, T. (2020). Bildung für Nachhaltige Entwicklung (BNE) in der Hochschullehre. *BMBF-Projekt „Nachhaltigkeit an Hochschulen: entwickeln – vernetzen – berichten (HOCHN)*", Bremen und Tübingen.

Butchart, S. H., Walpole, M., Collen, B., Van Strien, A., Scharlemann, J. P., Almond, R. E., ... & Watson, R. (2010). Global biodiversity: indicators of recent declines. *Science*, 328(5982), 1164-1168.

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design studies*, 47, 118-163.

D'Olivo, P., & Karana, E. (2021). Materials Framing: A Case Study of Biodesign Companies' Web Communications. *She Ji: The Journal of Design, Economics, and Innovation*, 7(3), 403-434.

De-la-Torre, G. E., Pizarro-Ortega, C. I., Dioses-Salinas, D. C., Rakib, M. R. J., Ramos, W., Pretell, V., ... & Dobaradaran, S. (2022). First record of plastiglomerates, pyroplastics, and plasticrusts in South America. *Science of The Total Environment*, 833, 155179.

Gros, J. (1993). *Mehr Weniger: Über den Umgang mit ökologischen Herausforderugen in der Designausbildung* ; Kolloquium Juni '93 ; Projekte und Positionen Deutscher Designschulen; Do. 3.6.- Sa. 5.6.1993 Hochschule für Gestaltung Offenbach a.M. ; Projektbuch. Kellner, Petra [Hrsg.], Offenbach, Germany.

Holzbach, M. (2014). *Material Grove.* Hochschule f. Gestaltung. ISBN: 978-3921997949.

Holzbach, M. (2021). Gestaltung in einer digitalen Welt – zur Designforschung und der Simultanität intuitiver und systemischer Prozesse im Materialdesign; in Kai Vöckler, Thilo Schwer (Hrsg.): Der Offenbacher Ansatz. Zur Theorie der Produktsprache. Transcipt Verlag, Bielefeld 2021, S. 432-446.

HRK (2018). *Für eine Kultur der Nachhaltigkeit.* Empfehlung der 25. Mitgliederversammlung der HRK am 06. November 2018 in Lüneburg.

Lineberry, H. S., & Wiek, A. (2016). Art and sustainability. Sustainability Science: An Introduction, 311-324.

Nimkulrat, N. (2010). Material inspiration: From practice-led research to craft art education. *Craft Research*, 1(1), 63-84.

BY-NC-SA 2024, Editorial Universitat Politècnica de València

Rognoli, V., Petreca, B., Pollini, B., & Saito, C. (2022). Materials biography as a tool for designers' exploration of bio-based and bio-fabricated materials for the sustainable fashion industry. *Sustainability: Science, Practice and Policy*, 18(1), 749-772.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., ... & Foley, J. A. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472-475.

Sauer C., Stoll M., Waldhör F. E., & Schneider M. (2022). *Architectures of Weaving.* Jovis Publisher. Berlin. ISBN 978-3-86859-739-4.

Wall, T., Österlind, E., & Fries, J. (2019). Art-Based teaching on sustainable development. In *Encyclopedia of Sustainability in Higher Education* (pp. 43-50). Cham: Springer International Publishing.

Zhou, Z., Rognoli, V., & Garcia, C. A. (2018, January). Educating designers through Materials Club. In Congress UPV: 4th International Conference on Higher Education Advances (HEAd'18) (pp. 1367-1375). Editorial Universitat Politècnica de València.

2024, Editorial Universitat Politècnica de València (cc) BY-NC-SA