Communication Technologies in Education

Proceedings of ICICTE 2024

Editors

Evangeline (Litsa) Marlos Varonis

& Anastasia (Nancy) Pyrini

Communication Technologies in Education

Proceedings of ICICTE 2024

Editors
Evangeline (Litsa) Marlos Varonis
and
Anastasia (Nancy) Pyrini

Greece 2024

ISBN: 978-9918-0-0253-5

Communication Technologies in Education: Proceedings of ICICTE 2024
ICICTE 2024, Chania, Greece, July 9 to 11, 2024

Citation of individual papers in APA Style:
Lastname, FirstInitial. (2024). Title of paper. In E. Varonis and A. Pyrini (Eds.), *The International Conference on Information Communication Technologies in Education (ICICTE 2024) Proceedings*, pp. n1-n2. ICICTE.

Editorial Board

Conference Organiser: PARAGON-eduTech

CONTENTS

Preface to the ICICTE 2024 Proceedings: Shaping the Future of Learning and Advocacy

Evangeline (Litsa) Marlos Varonis
Co-editor, ICICTE 2024 Proceedings

Welcome to the proceedings of ICICTE 2024, a platform that brings together researchers, educators, and industry experts from around the world to share insights and innovations shaping education, technology, and societal discourse. This collection of papers reflects a diverse and multidisciplinary approach to addressing the challenges and opportunities that arise in an era defined by rapid technological advances and complex global issues, presenting a rich exploration of innovative research and initiatives aimed at addressing contemporary educational challenges, enhancing learning experiences, and fostering sustainable, inclusive, and informed societies. From immersive learning technologies revolutionizing astronomy education to AI-driven personalization in higher education, and from strategies for combating fake news to integrating sustainability in media curricula, these contributions highlight the dynamic intersections of education, technology, and societal well-being.

Complementing this year's visionary keynote presentation by Eleni Chatzichristou, which sets the stage by demonstrating how interactive, experiential learning can deepen comprehension and engagement in scientific education, the presented research papers explore critical themes such as the reflections of school leaders on digital adaptation during the pandemic, innovative teaching methodologies, AI integration in personalized learning, the integration of sustainability goals into media education, and efforts to foster digital literacy and combat misinformation. Together, these contributions offer a comprehensive view of how technology, policy, and pedagogy intersect to shape the future of learning and advocacy through research-driven innovation and collaboration.

Several overarching themes emerge—chief among them, the necessity of adaptability, collaboration, and critical thinking in addressing the evolving challenges of the 21st century, underscoring the transformative power of technology in education while also highlighting the ethical, social, and professional considerations that accompany its use. The studies, each summarized in one sentence below emphasize the profound impact that thoughtful educational design and policy can have on shaping informed, resilient, and responsible citizens.

Keynote: Eleni Chatzichristou, *Astronomy Education through Immersive Learning and Enacted Astronomy*. This keynote presentation explores how immersive learning technologies and enacted astronomy, through interactive simulations, role-playing, and experiential engagement, are revolutionizing astronomy education by enhancing comprehension, retention, and student engagement with complex astronomical concepts.

Marcia Håkansson Lindqvist, *Exploring School Leaders' Lessons Learned During the Pandemic: Reflections in Retrospect*. This paper analyzes school leaders' reflections on the lessons they learned from using digital technologies during the pandemic, highlighting the increased efficiency of digital meetings, enhanced accessibility for students and parents, and the need for ongoing professional development in digital competence.

Maria Concetta Carruba, Alessandro Barca, & Mariella Tripaldi, *Methodologies and New Technologies: A Winning Combination for 21st Century Skills?* This exploratory study investigates the impact of active teaching methodologies and new technologies, such as ICTs and Artificial Intelligence, on primary and secondary school teachers' ability to foster life and soft skills in students, highlighting the importance of teacher training in effectively integrating digital tools into educational practices.

Georgios Karavasilis, *Evaluation of eLearning Platforms for Enhancing Digital Competencies of Vocational Education and Training (VET) Educators: A Comparative Study*. This study evaluates eLearning platforms for vocational education and training (VET) educators using a comprehensive rubric, identifying key strengths and weaknesses, offering recommendations for platform selection, and emphasizing the importance of digital competence development to enhance teaching effectiveness and learner outcomes.

Seyma Esin Erben & Hazal Koray Alay, *Women's Rights NGOs and Online Informational and Educational Content: A Comparative Analysis of the NGOs' Websites in Turkiye*. This paper (abstract only) examines and compares the online educational content of five women's rights NGOs in Türkiye, analyzing content types, accessibility, and organizational structure to assess their effectiveness in supporting advocacy and education within the context of fourth-wave feminism.

Antonis Gantzos, *Fake News Analysis: Predictive Capabilities and Implementation on the Web with Neural Networks.* The document describes the development and evaluation of machine learning models, primarily linear and non-linear neural networks, for fake news detection, integrating the best-performing model into a web application for real-time predictions.

Yianni Varonis, *News Digression and Political Polarization in the United States*. This article explores the historical evolution of political polarization in the United States, emphasizing how biased news media, social media algorithms, and misinformation have intensified divisions while highlighting media literacy as a potential solution to mitigate its effects on democratic governance.

Aránzazu García-Martínez, Víctor Gómez-Muñiz, Elisa Serrano-Ausejo, & Peter Mozelius, *A Proposal for an Immersive Virtual Reality Competencies Framework for History Teachers: Towards a Specialization of TPACK.* This paper proposes a specialized framework for integrating immersive virtual reality (iVR) into history education, building on the TPACK model and the European Digital Competences Framework to guide history teachers in developing the competencies required for effective use of iVR in teaching, emphasizing a gradual learning process from basic visualization to advanced content creation.

Konstantinos Karampelas, Anastasia Pyrini, George Sarrigeorgiou, Laura Screpanti, Benedetta Castagna, David Scaradozzi, & Ana Sović Kržić, *ROBOAQUARIA: Robots in Aquatic Environments to Promote STEAM and Environmental Awareness*. This paper explores the ROBOAQUARIA project, which integrates robotics into marine environmental education to promote STEAM learning and environmental awareness, showing that such interdisciplinary approaches can lead to significant cognitive, skill-based, and attitudinal outcomes for students, while also positively impacting school practices and teacher competencies.

Konstantinos Karampelas, Anastasia Pyrini, George Sarrigeorgiou, Konstantinos Tsolakidis, Emmanuel Rollinde, Malte Ubben, Maximilian Alexander Loch, & Nicoletta Pantela, *Aristarchus—Artistic Reality in School Education: Enacted, Reflective, and Collaborative Learning with the Human Orrery Space.* This study evaluates the effectiveness of using a human orrery in astronomy education through the ARISTARCHUS project, demonstrating how hands-on, interactive learning fosters deeper understanding, mental modeling, and positive attitudes toward science, while also examining the potential for transforming teaching practices across different educational systems.

Orestes Varonis, Evangeline Varonis, George Sarrigeorgiou, Anastasia Pyrini, & Darya Yegorina, *Empowering Sustainable Education: Reflections from the MIRACLE Pilot Initiatives*. The study evaluates the impact of climate change education impact on students and teachers across five countries; statistical analysis possible on Spanish students demonstrates significant improvements in knowledge and behaviour while attitudes, since initially high, show smaller gains, highlighting the effectiveness of targeted educational strategies incorporating augmented reality and comic creation for climate awareness.

Ġorġ Mallia & Monika Maslowska, *Sustainability in Media Education: Collaborative Strategies for Curriculum Development and Professional Empowerment by the SUMED Project.* The paper discusses the SUMED project, which involves collaborative efforts among five institutions across Europe to integrate sustainability goals into media education and the media industry, focusing on curriculum redesign and professional empowerment to equip students with sustainable media practices for future industry roles.

Apostolos Kostas, Dimitris Spanos, Filippos Tzortzoglou, & Alivisos Sofos, *Leveraging AI for Personalized Instruction in Higher Education: Initial Findings from the LEADER AI Project*. This paper presents preliminary findings from the LEADER AI project, which investigates the integration of AI-based and data-driven tools for personalized instruction in higher education, revealing both the opportunities and challenges associated with their adoption.

Aleksander Aristovnik, Lan Umek, & Dejan Ravšelj, *The Perceptions of Slovenian Higher Education Students on ChatGPT: A Comparison with Global Trends*. This paper examines the perceptions of Slovenian higher education students regarding ChatGPT and compares them to global trends, highlighting differences in usage patterns, ethical concerns, and support for regulation, with Slovenian students favoring academic writing applications but expressing stronger ethical concerns and less support for regulation compared to their international peers.

Apostolos Kostas & Christos Chanis, *ChatGPT and AI in K-12 Education: Views and Practices of Greek Teachers*. The study examines Greek teachers' perceptions of ChatGPT in education, highlighting its potential to enhance personalized learning while also identifying significant challenges such as data privacy concerns, algorithmic bias, and the need for better teacher training and policy frameworks for ethical AI use in education.

Mariano Sanz-Prieto, Elena López-de-Arana, Gema de-Pablo-González, *Newspiracy—Training Teachers in Post Truth Recognition*. The paper discusses the Newspiracy project, an educational initiative designed to equip teachers with tools and training to help students recognize and combat fake news and post-truth narratives, emphasizing the importance of critical thinking and media literacy in preserving democratic values.

The diverse research presented in these conference proceedings reflects a collective commitment to leveraging technology, innovative teaching methodologies, and data-driven insights to improve educational practices and societal outcomes, illustrating the dynamic interplay between technological advancements and human-centered learning. The papers also emphasize the need for inclusive and accessible approaches, whether in vocational training, women’s rights advocacy, or environmental education. By synthesizing these findings, this body of work provides a foundation for future collaboration, policy development, and continued exploration of how digital tools can be harnessed for transformative impact in education and beyond.

We extend our deepest gratitude to all contributors, reviewers, and organizers who made this event possible. It is our hope that these proceedings will inspire continued exploration, dialogue, and innovation as we collectively navigate the complexities of modern education and society. Let this be a call to action for educators, policymakers, and researchers alike to foster an inclusive, ethical, and forward-thinking educational landscape.

KEYNOTE ADDRESS: ASTRONOMY EDUCATION THROUGH IMMERSIVE LEARNING AND ENACTED ASTRONOMY

Eleni Chatzichristou
European Research Council Executive Agency
BELGIUM

Abstract

Immersive learning technologies have revolutionized education and transformed public outreach. In astronomy education, traditional learning methods (textbooks and lectures) cannot convey the vastness and complexity of the universe and its contents. In the concept of "enacted astronomy", students learn through interactive and experiential engagement with astronomical concepts using advanced technologies and role-playing activities. Using immersive learning techniques, the students can engage in interactive, three-dimensional experiences that bring astronomical concepts to life, enhancing comprehension and helping to retain the knowledge for future reference. Immersive learning techniques include, among others, simulations of celestial phenomena, virtual tours of the observed universe, interactive models of astronomical objects, or a human orrery. These provide students with a sense of scale that is important for understanding concepts such as planetary orbits, the structure of galaxies, or a sense of time and presence which can help in gaining perspectives of celestial phenomena such as the life cycle of stars or the vicinity of a black hole. It is also possible to combine these techniques, for instance a Virtual Reality orrery experience, in which case the users interact with an advanced, dynamic model of the solar system that incorporates real-time simulations of the motions of celestial bodies. This can apply to both classroom settings and public educational programs. In conclusion, immersive learning environments and experiential learning leverage the power of embodiment and active learning and entail cognitive and motivational benefits, stimulating curiosity and enthusiasm among students and making astronomy more accessible, engaging, and comprehensible to audiences at all levels of education.

Introduction

This contribution explores how immersive learning and enacted astronomy are revolutionizing the way we teach and learn about the universe. By leveraging advanced technologies and interactive methodologies, these approaches offer transformative educational experiences that enhance engagement, retention, and understanding. We cover the concepts of immersive learning and enacted astronomy, their benefits, and real-world examples of their application in astronomy education.

Immersive Learning and Enacted Astronomy

Immersive learning utilizes technology to create engaging and interactive environments, often through virtual reality (VR), augmented reality (AR), or simulations. This approach enhances engagement, retention, and understanding by providing hands-on experiences that simulate real-world scenarios. Enacted astronomy involves students in the active process of discovery and exploration through simulations, role-playing, and interactive activities. This educational approach promotes active learning, critical thinking, and a deeper understanding of astronomical concepts.

1. Immersive Astronomy

Virtual Reality (VR) allows users to experience astronomical environments in three dimensions, creating a sense of presence and immersion.

- **Adler Planetarium (Chicago IL, U.S.):** Offers VR tours of planetary surfaces, enabling students to explore Mars or the Moon as if they were there.

SkyRider Theater (Richmond BC, Canada)

- **:** Projects fantastic virtual-reality images onto a screen hung from the dome, with audience controls allowing participation.
- **Space Engine:** A VR software that lets users travel through the universe, exploring stars, planets, and galaxies.

Augmented Reality (AR) overlays digital information onto the real world, enhancing real-world experiences and providing educational content in context.

- **SkyView:** An AR app that helps users identify stars, constellations, and satellites by pointing their device at the sky.
- **Star Walk:** An AR app that provides detailed information about celestial objects and events when viewed through a smartphone.

Planetarium Shows with Advanced Technology: Modern planetariums use digital projectors and 3D simulations to create immersive star shows.

- **Hayden Planetarium (New York NY, U.S.):** Uses cutting-edge technology to provide immersive star shows and cosmic simulations.
- **Morrison Planetarium (San Francisco CA, U.S.):** Features a 75-foot digital dome offering an immersive experience of the night sky and beyond.

The Overview Effect is a profound cognitive shift reported by astronauts viewing Earth from space, characterized by a sudden recognition of the planet's fragility, interconnectedness, and the oneness of all life. This transformative experience often leads to a heightened sense of responsibility towards environmental stewardship and global cooperation. Examples of Immersive Astronomy Replicating the Overview Effect:

- **"Overview" by SpaceVR:** Uses footage from the International Space Station to provide a 360-degree view of Earth, aiming to evoke the same emotional and psychological impact.
- **"SpaceBuzz":** Initiated by Dutch astronaut André Kuipers, this project employs VR to take children on simulated space journeys, fostering environmental awareness and global consciousness.

2. Enacted Astronomy

Enacted astronomy is grounded in the theory of enaction, which claims that mental model building is interconnected with our perception of the external world through all our senses. Cognition arises through the dynamic interplay of brain, bodily action, and perception, necessitating that new abstractions be grounded in physical reality to be fully understood.

Interactive Simulations: Software that simulates astronomical phenomena, allowing students to manipulate variables and observe outcomes.

- **Universe Sandbox:** A physics-based space simulator merging gravity, climate, collision, and material interactions.
- **Stellarium:** An open-source planetarium software that lets users explore the night sky in real-time.

Role-Playing and Active Learning: Activities where students take on roles to solve problems or conduct missions.

- **AstroCamp:** An educational program where students simulate space missions, solving real-world challenges and contributing to NASA science missions.
- **Mission X: Train Like an Astronaut:** A global educational challenge encouraging students to learn about space exploration through physical activities and problem-solving tasks, part of NASA's Commercial Crew Program.

Real-World Examples of Enacted Astronomy

- **AstroPi**: A project by the European Space Agency that sends Raspberry Pi computers to the International Space Station for student experiments, combining coding, data analysis, and space science.
- **Goldstone Apple Valley Radio Telescope (GAVRT)**: Allows students to use a decommissioned NASA radio telescope for scientific research, engaging in authentic scientific inquiry and data analysis.

Human Orrery: Provides a kinesthetic learning experience, allowing participants to physically embody the movements of planets and other celestial objects.

- **Armagh Observatory and Planetarium (Armagh, Ireland):** Features a permanent outdoor human orrery for educational programs.
- **Cité de l'Espace (Toulouse, France):** Offers an outdoor human orrery where visitors can experience planetary movements firsthand.
- **Royal Greenwich Observatory (London, England):** Sets up temporary human orreries during educational events.
- **DIY Human Orrery Projects:** Schools and community groups create their own human orreries for classroom learning.
- **Aristarchus Project (Greece, France, Cyprus, Germany):** An educational initiative that uses a large-scale human orrery to make astronomy accessible and engaging.

The Future of Immersive Learning and Enacted Astronomy

Emerging Technologies

- **AI and Machine Learning:** Potential applications in personalized learning experiences and data analysis.
- **Holographic Displays:** Potential for creating even more immersive and interactive astronomical experiences.

Expanding Access

- **Online Platforms:** Increasing accessibility of immersive learning tools through online resources and virtual classrooms.
- **Global Collaboration:** Encouraging international cooperation in developing and sharing educational resources.

Conclusion

Immersive learning and enacted astronomy are transforming astronomy education by making complex concepts tangible and engaging. As technology continues to advance, these innovative approaches will play an increasingly crucial role in inspiring the next generation of astronomers and fostering a deeper understanding of the universe.

Author Details

Eleni Chatzichristou
European Research Council Executive Agency
Belgium
elthchatz@gmail.com

EXPLORING SCHOOL LEADERS´ LESSONS LEARNED DURING THE PANDEMIC: REFLECTIONS IN RETROSPECT

Marcia Håkansson Lindqvist
Mid Sweden University
Sweden

Abstract

In post-pandemic times, it is of interest to reflect in retrospect upon lessons learned in regard to leading, teaching, and learning with digital technologies during the pandemic. The aim of this paper is to explore and analyse school leaders' experiences of learning regarding the use of digital technologies during the pandemic. Using written learning reflections, school leaders reflected on lessons learned during the pandemic as the result of the rapid change to digital technologies for teaching and learning. School leaders saw possibilities in efficient digital meetings, adaptions in teaching and learning for students, as well as increased flexibility in digital leadership. The school leaders also reported new ways to reach students and parents, as well as collaboration. Although the pandemic, for many school leaders, resulted in a rapid shift in the use of digital technologies, school leaders saw benefits in this shift in the form of increased conditions for advancing professional digital competence. How school leaders will continue to retain and support these new lessons learned in their everyday work will be important in supporting of the use and advancement of digital technologies to support students' learning.

Introduction

During the COVID-19 pandemic, schools were forced to rapidly shift to online learning when many schools were closed. Following the pandemic the circumstances, sometime being described as disruptive for schools and educational systems, the role of the school leader became important. For many school leaders, returning to post-pandemic times demanded balancing a new context. This is within the context of what must be sustained and adapted in the old normal, new normal, and the next normal in the educational system. School leaders will have a key role in this process (Netolicky, 2019; Netolicky, 2020). Further, the process also emphasizes the inequities between schools, as well as in families and among (Netolicky, 2020).

In the post-pandemic state at present, the use of digital technologies has become widespread in schools. Here, the challenge will be not to just continue as before but to reflect upon experiences and identify changed directions (Hargreaves, 2020).

Zhao (2020) argues that seeing COVID-19 as a short-term crisis may exclude possibilities for lessons learned. This might involve missing possibilities in teaching and learning and changes which may be missed to change schools and education systems (Zhao, 2020). Identifying and using these new lessons learned as opportunities for school leaders in order to lead more effectively is important (Harris, 2020). This also includes the move from traditional school leadership to digital school leadership, involving, for example, digital meetings (Harris, 2020). Along the same line of thought, The World Bank (WB) also sees new possibilities in regard to digital technologies and teaching and learning, in which educational change which may be advanced and even hastened (WB, 2021).

Projects to strengthen digitalisation in Swedish schools and students and teachers' digital skills have been implemented in the Swedish context for many years (Jedeskog, 2007; Tallvid, 2015). However, though these investments have had impact, teaching and learning continues to be unclear despite investments and increased access (Swedish National Agency for Education, 2016; 2022). Leading for digitalisation is complex (Håkansson Lindqvist & Pettersson, 2019). Furthermore, the use of digital technologies does not automatically lead to increased use or improved outcomes for learners (European Commission, 2019). While digital technologies have entered Swedish schools (European Commission, 2018), the intentions of policy for teaching and learning with digital technologies and digital competence are not clear in practice (Olofsson, et al., 2020).

The Swedish National Agency for Education (SNAE) highlighted the necessity for professional development in the area of digitalisation for schools (SNAE, 2016). Several national efforts have been introduced in professional digital competence for school leaders. One of these efforts is a module on leading for digitalisation, which the SNAE implemented *Leading Digitalisation* (SNAE, 2018a). Another effort in meeting the new demands in digitalisation for school leaders has been to add digitalisation in the Swedish national principal training program (SNAE, 2018b). School leaders must be able to identify needs in their organization the pedagogical, administrative, and technical perspectives. A recent report by the SNAE (2022) showed that work remained to achieve the digitalisation strategy's aims. The most important results were that access continued to be good, although teachers lacked access to digital tools for supporting students with special needs (SNAE, 2022). There needed to be improved conditions for students to develop digital skills in searching for information and critical thinking. The overview reported that the effects of COVID-19 pushed the pace of digitalisation in schools (SNAE, 2022). However, which of these effects, or lessons learned, will remain is uncertain.

The aim of this paper is to explore and analyse school leaders' reflections regarding lessons learned during the pandemic in retrospect. The research question was: *What* *lessons learned do school leaders identify in post-pandemic leading, teaching, and learning?* Following this short introduction, background, method and finding will be presented. Thereafter, a discussion, practical implications, limitations and future research will be provided.

Background

Leithwood and Riehl (2005) describe successful school leadership as including four different functions: *setting the direction, developing the organisation, developing people,* and *developing teaching and learning.* These four functions involve how goals are formed and how the goals themselves are implemented in practice. The formulation and implementation and study of how the goals are implemented can be a driver of educational change and development (Fullan, 2015; Leithwood & Jantzi, 2006). In regard to school development through the use of digital technologies to support teaching and learning, Williams (2008) emphasizes the role of school leader during a time of rapid growth of digital technologies. The school leader is also of importance for supporting students' learning (Dexter, 2008). Further, the school leader is of importance for implementing digitalisation in schools as organisations (Pettersson, 2018).

Chua Reyes (2015) describes how school leaders navigated ICT educational reform. Here, school leaders described shifting identities, emerging roles, and ambivalent capacities when leading for technologies. These school leaders indicated that a change in leadership was needed, moving from a single leader role to leading teams of teachers (Chua Reyes, 2015). For teachers, this new role involves own learning, as well as supporting students' knowledge and skills for future schooling and work within a society where digitalisation is key and where school leader support is necessary. Starkey et al. (2017) reported that an education leader or system aiming to minimise the digital divide is a complex problem. How school leaders choose to support teachers in this work may also differ. Tolwinska (2021) reported two examples of school leaders' teacher-supportive behaviours. One group of school leaders focused on infrastructure and ensuring teachers had easy access to modern equipment. The other group of school leaders promoted a sharing culture that facilitated the development of professional digital competence.

Brockmeier et al. (2005) describe a threshold regarding professional digital competence that school leaders must cross before feeling prepared for leading for digitalisation. In early research, Flanagan and Jacobsen (2003) report many school leaders are hesitant regarding leading technology implementation due to the lack experience and formal training. They state that if school leaders are expected to lead their organisations toward using digital technologies, school leaders need professional digital competence. Schiller (2003) also discusses this line of thought regarding the need for professional digital competence. Anderson and Dexter

(2005) report that school leaders need adequate technology skills for their leadership roles. Schiller (2003) reports wide variations in what school leaders understand as technology competences and skills in practice, and therefore, the need for professional digital competence for school leaders. Acton (2021) shows that school leaders feel they have received very little professional development on how to be a leader of change and that research on professional digital competence for school leaders in practice has been limited.

Method

This paper focuses on school leaders' reflections on lessons learned during the pandemic in retrospect. The data were gathered from learning reflections (N = 22) written by school leaders. With inspiration from Moon's (2006) notion of learning journals, the school leaders were asked to reflect and identify lessons learned during the pandemic through learning journals. The learning reflections were written in the spring of 2024 by school leaders who were in middle of the Swedish National School Leader Programme, which is a three-year programme. The school leaders represented all levels of school, from preschool to upper secondary school. The majority of the school leaders were women. Further, the school leaders were new in their positions as school leaders. The school leaders had time to reflect on this question for a brief period during a lesson regarding digital technologies for leading, teaching, and learning. The learning reflections were short texts that were analysed using reflexive thematic analysis (Braun & Clarke, 2019). This involved reading and re-reading the school leader texts with a reflective approach and then allowing their themes to emerge in reflection. The 22 school leaders' reflections are identified in the Results section as "School Leader" (SL1 to SL 22; translations into English by the author).

Results

In this section the, the results are presented. In the analysis, three themes emerged: *Efficient meetings, Accessibility for meeting students and parents,* and *Professional digital competence.*

Efficient Meetings

One of the most important lessons learned after the pandemic for the school leaders in terms of digitalization was digital meetings as efficient meetings. Many of the school leaders' reflections referred to the opportunity to hold digital meetings. These meetings were seen to be efficient meetings, which saved time and were seen to be structured meetings: "Digital meetings were very time-saving" (SL4). A similar line of thought was expressed as structuring or streamlining: "How digital tools can help streamline things that previously took time and resources, such as digital meetings instead of physical ones" (SL2). Other school leaders reflected upon "More effective meetings" (SL18) as well the shift to more digital meetings: "How much more we could work digitally than we did then. More efficient time, for example, meetings etc." (SL19). Another school leader expressed: "Effective with team meeting, easier to check short things" (SL12). In the same line of thought one school leader noted increased efficiency: "Online meetings - teleworking. Efficient conversation paths. A lot of systematization" (SL14). One school leader reflected digital meetings being efficient as well as providing: "a rapid change to what digital [technologies] can contribute" (SL17).

The possibility to hold digital meetings from home was also seen a new, efficient way to work. For example, one school leader noted how digital meetings offer flexibility and at the same time availability: "Being able to work from home with administrative/digital meetings. I commute to work and I work from home one day/week. [I am] available online" (SL8).

Digital meetings were seen to be time-efficient and sustainable as they often involved less travel and less travel in time. The alternative of digital meetings was seen to be sustainable over distance and time: "More digital meetings instead of physical ones. Good because of the distances, but we have discovered that it is good to meet physically at regular intervals anyway" (SL3). "More meetings are possible when you can offer digital meetings" (SL7) was one reflection by a school leader. Digital meetings, according to the school leaders, work in many cases: "More efficient meetings as time in the car is reduced by being able to meet digitally Digital meetings work in many contexts" (SL21). Despite structured meetings and time-efficiency, the school leaders expressed the need for physical meetings as well. One school leader reflected on the need for both digital and physical meetings: "The most important [thing] learned after the pandemic is that it is possible to streamline meetings by conducting them digitally (avoiding travel, small talk, etc.). However, it is easy to miss social elements in the meeting as you cannot always read the participants" (SL9). Two of the school leaders reflected on the need for physical meetings as well as digital meetings: "Digital meetings save time between many meetings. However, they never replace the physical interaction" (SL13) as well as aspects lost in digital meetings: "Digital meetings save time. However, it has consequences because contact IRL disappears" (SL22).

In summary, one school leader also expressed digital meetings as providing another dimension to work at school.

> I started working as a principal in the middle of the pandemic so I may not have the picture before the pandemic completely. What I can see is that the meeting structure has become more efficient as several meetings have remained in digital form. Which means both time savings and fewer trips.

> You can be close to the school in another dimension. This is positive as I have many miles between my preschools. (S1)

Meeting Parents and Students

The school leaders also reflected upon lessons learned within meeting students and parents. Digital meetings offered opportunities to meet parents independent of time and space. Flexibility and availability were expressed: “After the pandemic we have become much more flexible. Meetings are more ad hoc with specific issues. Family participation has been easier to meet with development talks when it can also be done digitally” (SL15).

School leaders mean that digital teaching meant that it was easier to reach students with problematic absenteeism. One school leader expressed that it was easier [for teachers] to adapt and be more flexible in teaching and schoolwork assignments: “[I] Discovered benefits of this. Not only bad, development of own learning materials and digital homework through, for example, film and recorded material can be created when there is no disturbing noise from outside” (SL3). For students, this could lead to development in teaching: “We are more flexible today, lessons can take place in classrooms and via teams simultaneously or as decentralized training” (SL3). However, this school leader also noted caution in online teaching: “Distance learning is difficult, students lose focus and often become unmotivated. Semi-distance or decentralized training is better” (SL3). This could also include supporting students’ learning at home: “That it is easy to have meetings digitally. Homeschooling for students easier” (SL11).

One school leader discussed the link between teachers’ work with digital teaching and reaching students with problematic absenteeism, focusing on the benefits:

> That the teachers who were previously against digitization were “forced” into a way of working that they then saw several benefits in. That we have several students who are truant at a high [level] or skip school a lot. But they managed school better when they had to work more digitally (SL5).

Professional Digital Competence

Several of the school leaders reflected upon important lessons learned in regard to professional digital competence. One school leader expressed the resources provided to go digital with teachers: “The municipality has invested in both materials and training. This has allowed everyone to get started in a good way. Due to the pandemic and the need for digital meetings, everyone was challenged to try working digitally to varying degrees” (SL7). Another school leader saw lessons learned for organizational development through collaboration.

> The pandemic has created opportunities for me as a principal and my staff regarding digitization in the context of organizational development. We have developed digital forums and meetings that enable collaboration groups between preschools. The staff have also become accustomed to holding various meetings digitally. In X municipality, we now have a training course for all staff in municipal preschools. The leader gives the training via digital links. The training of the staff as expected to go well and much is due to the staff already having developed knowledge of participating in various digital forums. (SL6)

One lesson learned was also professional competence development in digitalisation for teachers. One school leader expressed that lack of professional digital competence became visible for teachers and students. This is important, according to one school leader who was interested in the continued work in school with Artificial Intelligence (AI): "The biggest lesson is that you can use IT for many adaptations. Teaching, access to data. Many had to quickly learn IT as a tool. AI is a feature that is coming by leaps and bounds. How do we relate to it [AI]?" (SL20). At the same time an important lesson learned was that gaps in professional digital competence for teachers and digital competence for students were made visible: "Many teachers and students have digital literacy gaps. This was discovered when we were forced into a digital environment"(SL2) .

In summary, the school leaders reflected upon many lessons learned in regard mainly to the opportunities provided after the pandemic as school leaders in terms of digitalization. A final reflection in summary by one school leaders expressed lessons learned:

> How quickly we could adapt to distance / remote teaching. How we got students with problems attendance in a different way in teaching. How we use digital platforms today naturally in our teaching, how we can streamline and conduct digital meetings. Meetings with colleagues, guardians, etc. (SL16).

Discussion

The aim of this paper is to explore and analyse school leaders' reflections regarding lessons learned during the pandemic in retrospect. The research question was: *What lessons learned do school leaders identify in post-pandemic leading, teaching and learning?*

For the school leaders in this study, an important lesson learned was found in the use of digital meetings. These meetings were seen as a possibility to structure and support work, but also time-efficient. The possibility to hold meetings from home or from the car appears to provide opportunities to arrange meetings in a more flexible manner that included accessibility and availability Here, school leaders' reflections on lessons learned appear to be linked to employing change by taking on this form of meetings and supporting the use of digital meetings in their organisations through ideas of acting as change agents (Acton, 2021) and to navigate change (Chua Reyes, 2015).

In regard to meeting students and parents, the school leaders reflected upon lessons learned in regard to accessibility for both those groups. For students, the use of digital technologies should support student learning. As the school leaders in this study reflect upon meeting students with special needs or problematic school absenteeism, this will be important work to continue, in order to reach all students. The same came be said to be true in regard to the lessons learned regarding reaching and meeting parents in a more flexible manner. In this sense, both of these lessons learned in the school leaders' reflections can be said to be important for supporting and advancing teaching and learning with digital technologies as an important part of fulling the intentions in policy in leading for digitalisation (SNAE, 2016; 2022). In teaching students, schools must achieve the intentions of the steering documents in terms of democracy, equity, the compensatory mission, and creating beneficial conditions for students as citizens of society (EC, 2019; OECD, 2022; UNESCO, 2017).

Perhaps the most interesting finding in this study is the school leaders' lessons learned in regard to how quickly the adaption online learning was carried out. As noted by the school leaders in this study, this shift appears to rapidly have advanced the use digital technologies, for example, for the use of digital meetings. However, according to the school leaders this also meant the need for digital competence became visible. Here, continued professional development will most likely be needed to support school leaders' work with their own professional digital competence, as well as the need to support teachers' and students' work. This will be important for school organizers. It is most likely that professional digital competence for school leaders will be necessary to take advantage of these lessons learned as new possibilities for student learning and educational change (Harris, 2020; WB, 2021; Zhao, 2021).

Practical Implications, Limitations and Future Research

The practical implications of this study focus on how school leaders advance the implementations of their lessons learned. For example, continued work with digital tools to support collegial meetings as well as meeting with students and parents should be supported by school organizers. Moreover, how school leaders together can share lessons learning with other school leaders will be of importance.

As this study is a small study, the findings could be explored further in larger studies. Future research could involve a larger study from the school leader perspective regarding lessons learned during the pandemic. Here, a survey could be administered for a larger number of school leaders, in order to attain a wider sample and deeper insights. Another interesting perspective would be to study parents' views on accessibility and availability to schools through the use of digital meetings.

References

Acton, K. S. (2021). School leaders as change agents: Do principals have the tools they need? *Management in Education*, *35*(1), 43–51.

Anderson, R. E., & Dexter, S. (2005). School technology leadership: An empirical investigation of prevalence and effect. *Educational Administration Quarterly, 41*(1), 49-82.

Braun, V. & Clarke, V. (2019) *Reflecting on reflexive thematic analysis. Qualitative Research in Sport, Exercise and Health, 11*(4), 589-597. DOI:10.1080/2159676X.2019.1628806

Brockmeier, L.L., Sermon, J. M. & Hope, W.C. (2005), Principals' relationship with computer technology. National Association of Secondary School Principals Bulletin, 89(643), 45-63.

Chua Reyes, V. (2015). How do school leaders navigate ICT educational reform? Policy learning narratives from a Singapore context. *International Journal of Leadership in Education, 18*(3), 365-385.

Dexter, S. (2008). Leadership for IT in schools. In J. Voogt, J. & G. Knezek (Eds), *International handbook of information technology in primary and secondary education* (pp. 542-554). Springer.

European Commission. (EC). (2018). Digital skills enter into Sweden schools. https://eurydice.eacea.ec.europa.eu/news/digital-skills-enter-sweden-schools#:~:text=The%20Swedish%20government%20decided%20to%20strengthen%20the%20national,national%20curriculum%20in%20compulsory%20and%20upper%20secondary%20schools

European Commission (EC). (2019). *Education and Training Monitor 2019*. Directorate-General for Education, Youth, Sport and Culture. https://education.ec.europa.eu/sites/default/files/document-library-docs/et-monitor-report-2019-sweden_en.pdf

Flanagan, L. & Jacobsen, M. (2003). Technology leadership for the twenty-first century principal. *Journal of Educational Administration, 41*(2), 124-142.

Fullan, M. (2015). *The new meaning of educational change*. Teachers College Press.

Håkansson Lindqvist, M., & Pettersson, F. (2019). Digitalization and school leadership: On the complexity of leading for digitalization in school. *The International Journal of Information and Learning Technology*, *36*(3), 218-230.

Hargreaves, A. (2020). What's next for schools after coronavirus? Here are 5 big issues and opportunities. *The Conversation.* https://theconversation.com/whatsnext-for-schools -after-coronavirus-here-are-5-big-issues and-opportunities-135004

Harris, A. (2020). COVID-19 – school leadership in crisis? *Journal of Professional Capital and Community, 5*(3/4), 321-326. https://doi.org/10.1108/JPCC-06-2020-0045

Leithwood, K. & Riehl, C. (2005), What do we already know about successful school leadership? In W.A. Firestone & C. Riehl (Eds), *A new agenda: Directions for research in educational leadership*, (pp.12-27). Teachers College Press.

Jedeskog, G. (2007). ICT in Swedish schools 1984–2004: How computers work in the teachers' world. *Seminar.net, 3*(1), 1-9.

Moon, J. A. (2006). *Learning journals: A handbook of reflective practice and professional development.* Routledge.

Netolicky, D.M. (2020). School leadership during a pandemic: navigating tensions. *Journal of Professional Capital and Community, 5*(3/4), 391-395. https://doi.org/10.1108/JPCC-05-2020-0017

Netolicky, D.M. (2019). Redefining leadership in schools: The Cheshire Cat as unconventional metaphor. *Journal of Educational Administration and History, 51*(2), 149-164.

Olofsson, A.D, Fransson, G. & Lindberg, J. O. (2020). *A study of the use of digital technology and its conditions with a view to understanding what 'adequate digital competence' may mean in a national policy initiative. Educational Studies, 46*(6), 727-743.

Organisation for Economic Co-operation and Development (OECD). (2022). *Trends Shaping Education 2022*. OECD Publishing, Paris. https://doi.org/10.1787/6ae8771a-en

Pettersson, F. (2018). Digitally competent school organisations: Developing supportive organisational infrastructures. *International Journal of Media, Technology & Lifelong Learning, 14*(2), 132-143.

Schiller, J. (2003). Working with ICT. Perceptions of Australian principals. *Journal of Educational Administration, 41*(2), 171-185.

Starkey, S., Sylvester, A., & Johnstone, D. (2017). Negotiating digital divides: Perspectives from the New Zealand schooling system. *Journal of Research on Technology in Education, 49*(1-2), 31-42.

Swedish National Agency for Education (2016). *IT use and IT competences in school* [IT-användning och IT-kompetens i skolan]. https://www.skolverket.se/getFile?file=3617

Swedish National Agency for Education. (2018a). *Leading digitalisation* [Leda digitalisering]. www.skolverket.se/kompetens-ochfortbildning/skolledare/styrning-ledning

Swedish National Agency for Education. (2018b). *National school leaders' training programme* [Rektorsprogrammet]. www.skolverket.se/kompetens-ochfortbildning/skolledare/ Rektorsprogrammet

Swedish National Agency for Education. (2022). *National Agency for Education's follow-up of the digitalisation strategy 2021* [Skolverkets uppföljning av digitaliseringsstrategin 2021]. https://www.skolverket.se/publikationsserier/rapporter/2022/skolverkets-uppfoljning-av-digitaliseringsstrategin-2021

Tallvid, M. (2015). *1:1 in the classroom: Analyses of a pedagogical practice in change* [1:1 i klassrummet: Analyser av en pedagogisk praktik i förändring 1:1 in the classroom]. [Doctoral dissertation, Center for Educational Science and Teacher Research and Research School in Educational Science, Acta Universitatis Gothoburgensis].

Tołwińska, B. (2021). The role of school leaders in learning schools to support teachers' use of digital technologies. *Technology, Knowledge and Learning 26,* 917–930.

United Nations Educational, Scientific and Cultural Organisation. (UNESCO). (2017). *Digital skills for life and work*. UNESCO Publishing.

Williams, P. (2008). Leading schools in the digital age: A clash of cultures. *School Leadership and Management*, *28*(3), 213-228.

World Bank. (2021, January 22). *Urgent, effective action required to quell the impact of COVID-19 on education worldwide.* https://www.worldbank.org/en/news/immersive-story/2021/01/22/urgent-effective-action-required-to-quell-the-impact-of-covid-19-on-education-worldwide

Zhao, Y. (2020). COVID-19 as a catalyst for educational change. *Prospects 49*, 29-33. https://doi.org/10.1007/s11125-020-09477-y

Author Details

Marcia Håkansson Lindqvist
Department of Education
Mid Sweden University
SWEDEN
marcia.hakanssonlindqvist@miun.se

ACTIVE METHODOLOGIES AND NEW TECHNOLOGIES: A WINNING COMBINATION FOR 21ST CENTURY SKILLS?

Maria Concetta Carruba and Alessandro Barca
Università Telematica Pegaso
Mariella Tripaldi
Università degli Studi Aldo Moro Bari[1]
ITALY

Abstract

For some time now, the teaching-learning paradigm has been centered on the individual, the active author of his or her learning process. From this principle emerges the need, on the part of educational institutions, to use active methodologies, and clear expressions of innovative teaching practices, albeit largely already shared by illustrious exponents of the academic sciences such as Dewey, Freire, Bruner, and Vygotskij, to name but a few. However, which active methodologies are inclusive and innovative enough to develop and acquire life and soft skills today, and how do teachers perceive these? Furthermore, today, where technology is rampant in all its forms, can the so-called ICTs or ICTs be valid supports to the teaching-learning process? These are just some of the questions we have asked ourselves and which we have tried to answer in the exploratory study involving us in the training of primary and secondary school teachers. The aim of this study was primarily to investigate, including through semi-structured questionnaires:

- What are teachers' knowledge and beliefs regarding active and innovative methodologies supported by new media?
- How does the training course influence teachers' ability to implement the methodologies and utilize the tools and applications introduced during the training?
- How do teachers perceive the practical value of these methodologies and technological innovations in enhancing their daily teaching practices and supporting students' development of life and soft skills?

[1] The contribution is the result of the shared work of the authors. However, the "Introduction" is attributed to Mariella Tripaldi; "The research" to Alessandro Barca; "The results" to Alessandro Barca and Mariella Tripaldi; and the "Active Learning role", the "Students' Engagement", and the "Teachers' training" to Maria Concetta Carruba. The abstract and conclusions are to be equally attributed to all authors.

Introduction

Today, educational institutions are increasingly tasked with addressing the demands of digitalization, adhering to European standards and the objectives outlined in the 2030 Agenda (United Nations, 2015). Significant disparities have been identified at regional, institutional, and classroom levels regarding digital integration. The advancement of digital innovation in schools often depends on individual teachers who exhibit particular enthusiasm or passion for digitalization, leading to substantial variability and gaps in implementation.

For some time now, the teaching-learning paradigm has centered on the individual as the active agent in the learning process. This principle necessitates that educational institutions employ active methodologies, which are clear expressions of innovative teaching practices. These methodologies, long advocated by prominent academic figures such as Dewey, Freire, Bruner, and Vygotskij, aim to be inclusive and effective in developing essential life and soft skills. However, questions remain about which active methodologies are sufficiently inclusive and innovative in today's context, and how teachers perceive them. Additionally, in a society where technology permeates all aspects of life, there is a need to examine whether Information and Communication Technologies (ICTs) can effectively support the teaching-learning process.

This exploratory study aims to provide a platform for teachers to articulate their classroom experiences and insights. The primary objective of the research is to contextualize these experiences, assess the needs arising from them, and propose a framework for collective change. The study involved the training of primary and secondary school teachers, using semi-structured questionnaires to investigate their knowledge and beliefs about active and innovative methodologies supported by new media. Furthermore, it examines the impact of the training on the teachers' ability to implement these methodologies and tools in their practice, as well as their perception of the value these methodologies and technological innovations bring to their daily practice and the acquisition of life and soft skills.

Through an analysis of the findings, the study seeks to understand teachers' interactions with recent digital innovations and their implications for teaching strategies and approaches within the school environment. Ultimately, the research aims to start with the context, reflect on needs, and propose a model for initiating collective change in the integration of digitalization in education.

The Research

An exploratory study was conducted using a mixed-method approach to obtain both quantitative and qualitative data on the topics of digital innovation, inclusive education, and teacher training. Data collection was performed via an online questionnaire consisting of 44 items, 11 of which were open-ended. These items were evenly distributed across the three areas of investigation:

1. Digital innovation
2. Inclusive education
3. Teacher training

The structured questionnaire facilitated the acquisition of statistically meaningful data through closed-ended questions, which were equally divided between multiple-choice and checkboxes with multiple possible answer options. The open-ended questions, designed in paragraph format, allowed respondents to express personal reflections, share classroom experiences, and elaborate on their answers based on personal and professional insights.

Quantitative data were analyzed using Statistical Package for the Social Sciences (SPSS) software, employing a multivariate approach to uncover underlying patterns and relationships. The qualitative responses were examined to trace the connections between closed and open-ended questions, and more importantly, to identify the frequency and priority of specific words, terms, and needs.

This exploratory study targeted teachers from all educational levels across Italy, encompassing the North, Center, South, and Islands regions. A simple random sampling method, as described by Noor, Tajik, and Golzar (2022), was employed to select the sample of teachers. The study garnered 200 responses, a figure that reflects the challenges of reaching teachers across the Italian territory without a ministerial-level search mechanism. Although the number of responses is representative rather than exhaustive, it provides a valuable snapshot of regional differences in educational practices and needs.

The primary aim of the study was to provide a platform for teachers to voice their experiences and perspectives, contextualize their needs, and propose a model for collective change. By analyzing teachers' experiences with recent digital innovations and their implications for teaching strategies, the research offers insights into the integration of digitalization in education and its potential to foster inclusive and effective learning environments.

The Results

The data analysis highlighted the significance of incorporating technologies in schools, including cutting-edge tools such as Artificial Intelligence (AI), within a pedagogical framework that emphasizes active learning. The difference lies not in the mere presence of the tool but in the manner in which the teacher designs and implements the instructional activity in the classroom.

Central to this approach, particularly in addressing the needs of students with Special Educational Needs, is the role of student engagement. Word frequency analysis revealed the teachers' need to focus on instructional strategies that make students "active" participants during activities, thereby promoting a teaching approach that encourages the development of each individual's potential, without exception.

The analysis of the questionnaires reveals a strong correlation between teachers' perceived risks regarding the introduction of Artificial Intelligence in schools and the lack of adequate training for teachers. Consequently, while teachers generally acknowledge the potential of AI, they fear they lack the necessary skills to prepare students to use it effectively. This concern is underscored by the frequent mention of the term "passive consumer", highlighting teachers' primary fear that students might not engage actively with AI technologies.

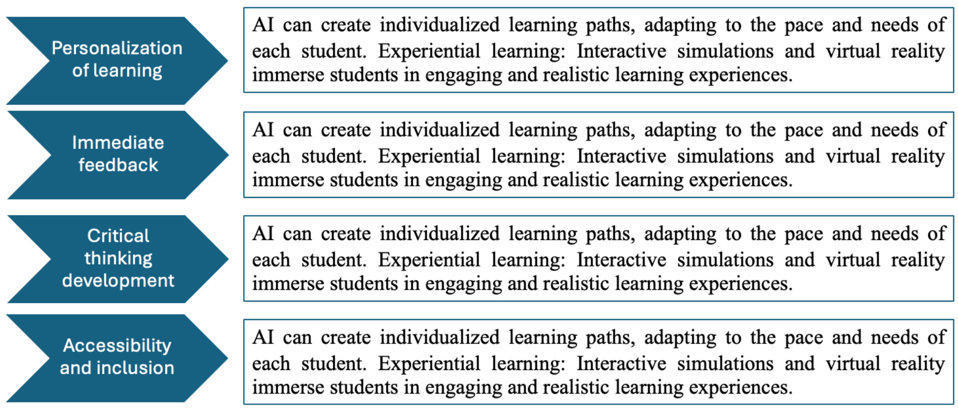
Nowadays, Artificial Intelligence is part of the world of science education, revolutionizing learning, and opening new frontiers for teaching (Nihal & Akbay, 2023). The use of AI-based tools offers a range of opportunities to make science learning more engaging, effective, and personalized. However, this evolution requires teachers to develop new skills to take full advantage of the potential of AI and guide students in this new educational context. In this paper, we can explore the teachers' feelings on AI guided by some questions.

Question 1. What are the benefits of AI in science education?

AI has the potential to revolutionize education and promote student engagement in a meaningful way (see Figure 1). However, it is important to address the challenges and obstacles with appropriate strategies and training to make the most of the potential of this technology. Conscious use of AI can transform schools into a more inspiring, effective, and inclusive learning environment, preparing students for the challenges of the future.

Figure 1

Four Benefits of AI in Science Education



All the technologies mentioned by teachers in the collected responses are consistently linked to active teaching strategies when cited as good practices or positive examples of technology use. From the analysis of the open-ended responses, it emerges that teachers believe that, to adequately prepare students for acquiring the skills needed to meet the demands of a complex society and job market, it is essential to provide them with appropriate technological training. This training should ensure that students are active users of the tools.

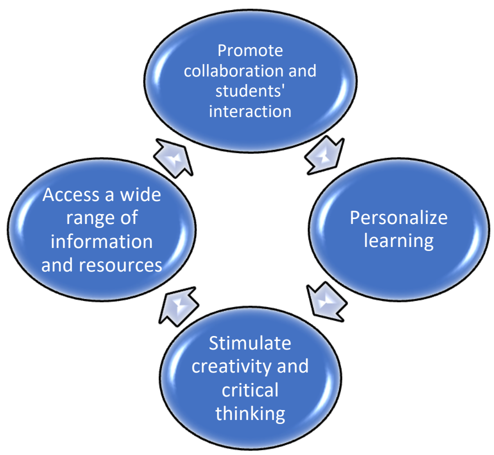
This premise implies that teachers must learn to become conscious guides for their students, necessitating specific training not only in digital competencies but also in the broader skills required to empirically understand and address student needs. Both digital skills and life skills will be indispensable for students. It is through the integration of these competencies that students will find the support needed to navigate the complexities of contemporary society.

To meet these new demands, teachers highlight two major training needs: firstly, training in active teaching methodologies, and secondly, but equally important, training in how to promote student engagement. From the teachers' perspective, as revealed by the analysis of open-ended responses, placing the student at the center with their needs, following them by proposing a pedagogy that makes them the main actor, attending to their emotional needs, and training them in the digital skills required by our society, will enable schools to truly address the educational needs of students in this era.

The Active Learning Role

The Active learning model (Patiño et al, 2023) represents an innovative pedagogical approach that places students in an active role in the learning process at the center. It contrasts with traditional teaching, which is based on the passive transmission of notions, and focuses on engaging experiences that stimulate students' curiosity, participation, and responsibility. Digital innovation plays a key role in facilitating and enhancing active learning.

Figure 2
Active Learning Process



Indeed, digital technologies offer a wide range of tools and resources that can be used to:

- Promote collaboration and interaction among students: e-learning platforms, online forums, social media, and virtual learning environments (VLEs) enable students to work together, share ideas, and build knowledge collectively.
- Personalize learning: instructional software, educational apps, and artificial intelligence systems can tailor content and activities to the needs and learning pace of each student.
- Stimulate creativity and critical thinking: digital tools such as video cameras, editing software, coding, and simulations allow students to explore, experiment, and create independently.
- Access a wide range of information and resources: the Internet, digital libraries, and online archives make an unlimited amount of data and learning materials on any subject available to students.

The active methodologies most frequently featured in teachers' responses are:

- Flipped classroom (Huang et al, 2023): students learn new concepts independently at home, through videos, ebooks, or other digital content, and in class discuss, deepen, and apply what they have learned with collaborative and interactive activities.
- Problem-solving and project work (Diwan et al, 2023): students work in groups on real problems or research projects, using digital technologies for data collection, communication, and presentation of results.
- Gamification (Bezzina & Dingli, 2023): the use of game elements, such as prizes, badges, and leaderboards, makes learning more fun and motivating for students.
- Augmented and virtual reality-based learning (Geroimenko, 2023): these immersive technologies allow students to have realistic and interactive learning experiences in virtual or overlaid contexts with the real world.

From the teachers' views, based on the questionnaire's answers, to introduce such sophisticated digital innovations, such as AI, it is not possible not to start by renewing traditional teaching through the proposal of active teaching that puts the student in a position to be a co-constructor of his or her learning. If the teacher does not decentralize, embracing the active role of the student and the classroom, there is a risk that innovation, even with sophisticated technologies such as AI, will become merely a tool devoid of any genuine transformative effect.

The Students' Engagement

Student engagement is a key factor in effective and sustained learning. It is a state of active participation and interest in the learning process, manifested through curiosity, motivation, collaboration, and engagement. Artificial intelligence can play a significant role in promoting student engagement in several ways:

1. Personalization of learning

AI can analyze individual student data, such as their learning styles, interests, and progress, to create personalized learning experiences. This can include choosing content and activities suited to each student's level, providing real-time feedback, and creating individual learning paths.

2. Interactive and engaging learning:

AI can be used to create interactive and engaging learning experiences that capture students' attention and motivate them to learn. This can include the use of educational games, simulations, virtual and augmented reality, chatbots, and other immersive technologies.

3. Immediate feedback and individualized support:

AI can provide students with immediate and individualized feedback on their tasks and progress. This can help them identify their strengths and weaknesses, correct errors, and improve their performance.

4. Individualized tutoring and support:
AI can be used to provide students with individualized tutoring and support. This can include access to intelligent chatbots that can answer students' questions, provide explanations of difficult concepts, and help them solve problems.

5. Development of future skills:
AI can help students develop key future skills such as critical thinking, problem-solving, communication, and collaboration. This can be done through project-based learning activities, role-playing, and simulations.

The principal AI tools individualized by teachers as inclusive and useful tools to promote learning engagement are:

1. Intelligent tutoring systems: these systems can assess students' knowledge and provide them with personalized explanations of difficult concepts.
2. Adaptive learning platforms: these platforms provide students with content and activities tailored to their learning level and interests.
3. Educational simulations and games: these immersive experiences allow students to learn in a fun and engaging way.
4. Intelligent chatbots: these chatbots can answer students' questions, and provide support and encouragement.

Teachers' Training

What emerges very clearly and across the board in all areas and the totality of the responses analyzed is that to use AI competently in school, the teacher needs to be trained. There is a fear of misusing the tool, of not being able to anchor it to purely didactic goals, of risking an introduction devoid of pedagogical and educational purposes.

All teachers have highlighted that they need specific training.

Question 2. And, therefore, what new skills do teachers need?

In order to effectively integrate AI into their teaching, teachers need to develop several key competencies. First, they require digital skills to understand and use AI tools effectively in educational settings (Al Darayseh, 2023). Instructional design skills are also essential, enabling teachers to create hybrid learning paths that combine AI with traditional methods. Additionally, assessment skills are crucial to accurately evaluate student learning in hybrid contexts. Teachers must also cultivate inclusive skills to guide students in using AI responsibly and independently. Lastly, ethical skills are vital, as teachers must be able to reflect on the ethical implications of AI and foster its responsible use in the classroom (Nguyen et al., 2023).

Figure 3

Five Skills Needed to Integrate AI into Teaching

- Digital skills: Know and be able to use artificial intelligence tools for teaching.
- Instructional design skills: Know how to design hybrid learning paths that integrate AI with traditional teaching.
- Assessment skills: Know how to assess student learning in a hybrid learning context.
- Inclusive skills: Know how to guide students in using AI tools and learning independently.
- Ethical skills (Nguyen et al, 2023): Reflect on the ethical implications of using AI in the classroom and promote responsible use of technology.

Conclusion

In conclusion, the exploratory study highlights a significant need for teacher training in the effective integration of AI within Italian schools. Teachers emphasized that technological innovation must be accompanied by innovation in teaching practices. They have a clear understanding of the benefits of incorporating AI in education, particularly in fostering inclusive education. However, there are lingering concerns regarding the use of AI and the instructional design that leverages AI as a comprehensive learning environment, rather than merely as a tool. This statement emphasizes that, for AI to be a transformative force in education, professional development must address two critical areas: digital competencies and pedagogical skills. Teachers need not only technical training in AI and digital tools but also guidance on adapting their teaching methods to foster a learning environment where AI can be effectively utilized. This dual focus is essential because, without a robust understanding of both the technology itself and the strategies to integrate it meaningfully into the classroom, AI risks being underutilized or even misapplied. As a result, professional development programs should aim to empower teachers to understand, adapt, and implement AI in ways that enhance student engagement, support differentiated learning, and foster critical and creative thinking.

References

Al Darayseh, A. (2023). Acceptance of artificial intelligence in teaching science: Science teachers' perspective. *Computers and Education: Artificial Intelligence*, *4*, 100132.

Bezzina, S., & Dingli, A. (2023, July). Rethinking gamification through artificial intelligence. In *International Conference on Human-Computer Interaction* (pp. 252-263). Cham: Springer Nature Switzerland.

Diwan, C., Srinivasa, S., Suri, G., Agarwal, S., & Ram, P. (2023). AI-based learning content generation and learning pathway augmentation to increase learner engagement. *Computers and Education: Artificial Intelligence*, *4*, 100110.

Geroimenko, V. (Ed.). (2023). *Augmented Reality and Artificial Intelligence: The Fusion of Advanced Technologies*. Springer Nature.

Huang, A. Y., Lu, O. H., & Yang, S. J. (2023). Effects of artificial intelligence–Enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. *Computers & Education*, *194*, 104684.

Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B. P. T. (2023). Ethical principles for artificial intelligence in education. *Education and Information Technologies*, *28*(4), 4221-4241.

Noor, S., Tajik, O., & Golzar, J. (2022). Simple random sampling. *International Journal of Education & Language Studies*, *1*(2), 78-82.

Patiño, A., Ramírez-Montoya, M. S., & Buenestado-Fernández, M. (2023). Active learning and education 4.0 for complex thinking training: analysis of two case studies in open education. *Smart Learning Environments*, *10*(1), 8.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations General

Assembly. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Author Details

Maria Concetta Carruba
Università Telematica Pegaso
mariaconcetta.carruba@unipegaso.it
Italy

Alessandro Barca
Università Telematica Pegaso
Italy
alessandro.barca@unipegaso.it

Mariella Tripaldi
Università degli Studi Aldo Moro Bari
Italy
Mariella.tripaldi@uniba.it

EVALUATION OF eLEARNING PLATFORMS FOR ENHANCING DIGITAL COMPETENCIES OF VOCATIONAL EDUCATION AND TRAINING (VET) EDUCATORS: A COMPARATIVE STUDY

Georgios Karavasilis
School of Pedagogical and Technological Education
GREECE

Abstract

This paper explores the integration of eLearning platforms in Vocational Education and Training (VET), focusing on enhancing digital competencies among educators. Through systematic evaluation using a developed rubric, three eLearning platforms were assessed for their alignment with pedagogical goals and learner needs. Findings revealed strengths and areas for improvement in course design, learning objectives, assessment strategies, and accessibility. Recommendations were provided for VET teachers, institutions, and policymakers to leverage technology effectively for educational enhancement. Overall, the study emphasizes the importance of informed decision-making and continuous improvement in fostering engaging and inclusive digital learning environments in VET settings.

Introduction

In the digital age, the role of educators, particularly those in Vocational Education and Training (VET), has undergone significant evolution. With the rapid integration of digital technologies into everyday life and work, VET educators are tasked not only with keeping pace with technological advancements but also with nurturing the digital skills of their students. However, this transition is not without its challenges. VET teachers often grapple with varying levels of digital literacy, limited access to technology infrastructure and resources, and the constant need for professional development to remain adept in an ever-changing technological landscape.

Despite these challenges, digital competence frameworks emerge as indispensable tools in equipping VET educators with the necessary skills and knowledge to navigate the digitalized educational landscape effectively. These frameworks offer structured guidelines for skill development and provide avenues for continuous professional growth. By addressing the specific needs and challenges faced by VET educators, digital competence frameworks play a pivotal role in ensuring the delivery of high-quality, future-oriented education.

The purpose of this paper is to critically evaluate the effectiveness of eLearning platforms in developing digital competencies among VET educators. Drawing upon the Quality Matters standards and the DigCompEdu framework, a comprehensive rubric has been developed to assess the alignment of eLearning platforms with the digital competence needs of VET educators. Through this evaluation, the paper aims to provide insights into the strengths and limitations of eLearning platforms in fostering digital competencies, offering valuable implications for practice and policy.

Importance of Digital Competence Frameworks for VET Educators

Digital competence frameworks serve as indispensable tools for VET educators, offering a multitude of benefits:

Guidance on Skill Development: These frameworks provide clear guidelines on the digital skills and competencies essential for effective teaching in the digital age. For example, frameworks like DigCompEdu (Redecker, 2017) outline specific competencies such as digital content creation and communication, guiding educators on the skills they need to acquire and develop to enhance their teaching practices.

Standardization and Benchmarking: By establishing a standardized set of competencies, digital competence frameworks enable educators to benchmark their skills against established criteria. This promotes consistency in digital education across different contexts and regions, facilitating the exchange of best practices and ensuring quality assurance in digital teaching methods.

Support for Continuous Professional Development: Digital competence frameworks play a crucial role in supporting educators' ongoing professional development. They identify areas for improvement based on evolving technological trends and pedagogical needs, providing educators with targeted pathways for skill enhancement. For instance, frameworks like the UNESCO-UNEVOC framework (UNESCO-UNEVOC, 2022) offer toolkits and resources to help VET educators assess their digital skills and access relevant training opportunities.

Enhancement of Teaching and Learning: By integrating digital tools and methodologies, these frameworks empower educators to enhance their teaching strategies, making learning more engaging and effective for students. For example, frameworks like the UNICEF Digital Competency Framework (UNICEF Regional Office for Europe and Central Asia (EACARO), 2022). for Teachers emphasize the use of innovative digital technologies to promote active learning and critical thinking skills among students.

In summary, digital competence frameworks serve as invaluable resources for VET educators, offering guidance, standardization, support for professional development, and opportunities for enhancing teaching and learning in the digital era.

Digital Competence Frameworks

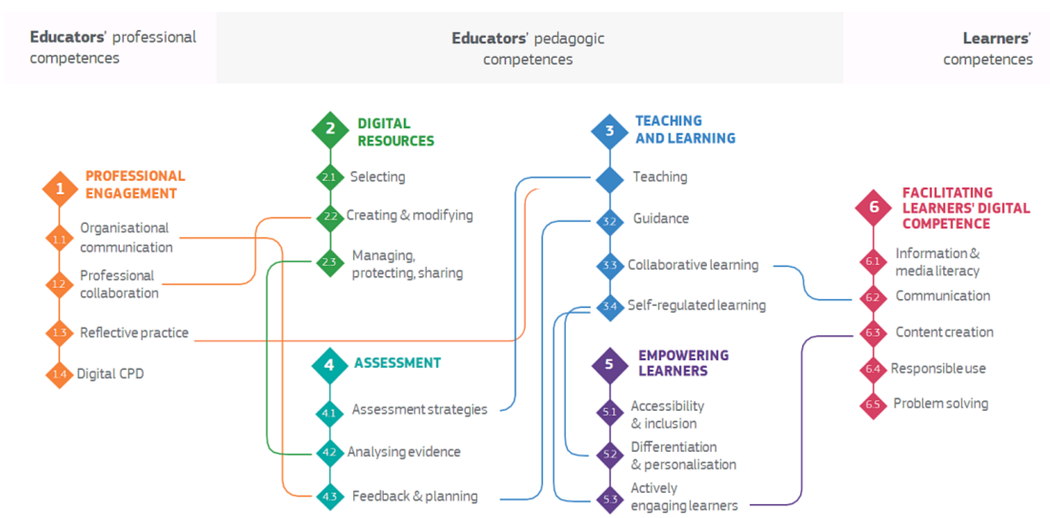
Several notable frameworks have been developed to support the digital competence of VET educators.

DigCompEdu (European Commission)

The Digital Competence Framework for Educators (DigCompEdu) is a scientifically validated framework developed by the European Commission. It describes what it means for educators to be digitally competent and provides a comprehensive reference for supporting the development of digital competences in educators across Europe. DigCompEdu addresses educators at all levels, from early childhood education to higher education and adult learning, encompassing general and vocational education and training, special needs education, and non-formal learning contexts. The framework organizes digital competences into 22 competencies across six key areas (Redecker, 2017).

Figure 1

The DigCompEdu framework (Redecker, 2017)



UNESCO-UNEVOC Framework

The UNESCO-UNEVOC framework focuses on the development of digital skills for VET teachers and trainers. It supports VET providers by addressing the impacts of digitalization on VET, identifying new digital skills and competencies required, and providing toolkits to help VET providers assess their needs and progress. This framework emphasizes the importance of equipping VET educators with the skills needed to effectively use digital tools and technologies in their teaching practices (UNESCO-UNEVOC, 2022).

UNICEF-ECARO Digital Competency Framework for Teachers

The UNICEF framework aims to empower teachers, improve online teaching, and promote innovation in education. It supports stakeholders in fostering educators' digital competences to ensure inclusive and quality education for all children, with a particular focus on the most vulnerable. The framework promotes the development of 21st-century digital skills and competencies necessary for professional growth, equity, and inclusion (UNICEF Regional Office for Europe and Central Asia (EACARO), 2022).

Significance of Digital Competence Frameworks

Collectively, these frameworks contribute to the digital transformation of education by providing VET educators with guidance and resources to navigate the challenges and opportunities of a digitalized world. By adhering to these frameworks, VET educators can enhance their teaching practices, better prepare their students for the future, and contribute to the overall improvement of the educational landscape.

Methodology

In today's dynamic educational environment, integrating digital tools and platforms is essential, particularly within the context of initiatives such as Erasmus+ that promote innovation and collaboration. This study aims to critically investigate the extent to which e-learning platforms, developed through Erasmus+ projects, align with the European Digital Competences for Teachers (DigCompEdu) (Redecker, 2017) framework in fostering the digital competences of VET teachers. To achieve these aims, the research adopts a descriptive comparative research design, focusing on the digital competences required by VET teachers.

Research Objectives

Objective 1: Evaluation of Alignment with the DigCompEdu Framework

- Assessment of Alignment: Evaluate the degree to which the e-learning platforms developed in Erasmus+ projects align with the DigCompEdu framework.
- Exploration of Responsiveness: Investigate how effectively these platforms address the key dimensions and standards described in DigCompEdu.

Objective 2: Development of an Analytical Alignment Rubric

- Creation of an Analytical Rubric: Develop a rubric based on Quality Matters standards, integrating relevant criteria from DigCompEdu to assess the alignment of e-learning platforms.
- Validation of the Rubric: Ensure the rubric is clear, systematic, and applicable to different types of e-learning content.

Objective 3: Analysis of the Evaluation Results and Identification of Positive and Negative Features

- Examination of Collected Data: Analyze data collected using the rubric to evaluate the alignment of e-learning platforms with DigCompEdu.
- Identification of Characteristics: Determine the positive and negative features of the evaluated platforms concerning their alignment with DigCompEdu standards.
- Utilization of Qualitative and Quantitative Techniques: Apply both qualitative and quantitative analysis techniques to accurately interpret the evaluation results.

Objective 4: Provide a Validated Quality Assurance Tool for the Evaluation of E-learning Platforms

- Development of a Comprehensive Rubric: Create a detailed rubric that includes key criteria for assessing the alignment of e-learning platforms with DigCompEdu.
- Ensuring Reliability and Validity: Conduct rigorous testing and validation procedures to ensure the rubric's reliability and validity.
- Dissemination of the Rubric: Share the validated rubric with the VET community, including teachers and institutions, to aid in informed decision-making when selecting appropriate e-learning platforms.
- Provision of Guidelines and Resources: Offer guidelines and resources for effectively using the rubric to assess platform suitability and inform digital skills training initiatives in the VET sector.

This research holds significant value for educators, platform developers, and policymakers involved in digital education. Its findings can guide the enhancement of e-learning platforms, ensuring their effectiveness in promoting the digital competence of VET teachers. Additionally, the insights gained from this study can shape future strategies for designing and improving digital learning tools, thereby fostering a more inclusive and effective learning environment for VET educators.

Data Collection Process

For the purposes of this study, which focuses on eLearning platforms designed to enhance the digital competencies of VET educators in Greece, data collection was conducted using the Erasmus+ Results Platform (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2017). The selection process was guided by the following criteria to ensure relevance and quality:

1. Project Status - Completed: Only completed projects were considered, as they have undergone a comprehensive three-stage evaluation process, including selection for funding, mid-term evaluation, and final evaluation. This ensures the quality and impact of the results.
2. Actions - Key Action 2: Cooperation among organizations and institutions, particularly those involved in the production of open educational resources, was prioritized for this study.
3. Type of Action - VET and Adult Education: Actions related to vocational education and training (VET) and adult education were chosen due to their focus on training for VET teachers, digital readiness initiatives, and strategic partnerships spanning multiple sectors.
4. Sector - VET: The VET sector was specifically targeted to align with the study's focus on vocational education and training.
5. Keywords: To refine the search results, keywords such as "Digital Competence" and "Digital Skills" were utilized.

Further processing of the search results was conducted manually in an Excel workbook, applying the following additional criteria:

1. Year of Project Approval: Projects approved in 2021 and 2022 were selected to ensure the relevance and currency of the data.
2. Participation of Greece: Projects involving Greek participation were prioritized to maintain the study's focus on enhancing digital competencies of VET educators in Greece.
3. Project Topic: Projects that included the terms "digital skills" or "digital competences" in their descriptions were retained. Additionally, projects related to the initial and in-service training of VET teachers were included to explore the training offered pertaining to digital skills.

In the final phase, projects were further narrowed down based on the availability of eLearning platforms in the Greek language.

Following this meticulous data collection methodology, the validation of the rubric was conducted by evaluating the identified eLearning platforms.

Platforms under Study

XR_SKILL: Enhancing Soft Skills through Extended Reality in the Post-COVID Era

The XR_SKILL learning platform utilizes Virtual Reality (VR) technology to provide self-paced learning modules focused on enhancing soft skills. With five modules, it addresses topics such as stress management, emotional intelligence, and game-based learning for skill development. Notably, it features a dedicated game to aid teachers and future educators in improving their time and stress management abilities (XR_Skill, 2023).

DigiREACT: Experience Brewing Assistant for Vocational Training

DigiREACT is an Employee Experience Platform (EXP) designed to facilitate digital transformation in corporate training. Through a blend of gamification and AI technologies, it offers personalized training pathways, progress tracking, and performance analytics. Aimed at enhancing workforce productivity, the platform empowers trainers to adapt training content to evolving learning needs and styles, facilitating change management within hybrid teams (DigiREACT, 2022).

GROOVE: Digital Transformation of the VET Sector

GROOVE serves as an online learning space and resource hub for VET providers, teachers, trainers, and stakeholders. It offers instant access to a diverse range of learning resources and Open Educational Resources (OERs) in a user-friendly format. Hosting training materials aligned with the DigComp framework, GROOVE aims to enhance the digital competence of VET educators and trainers through accessible and well-organized content (GROOVE, 2021).

Rubric Development

The rubric development process is based on the specifications with the relevant criteria developed by Quality Matters (2015) for its Continuing and Professional Development Rubric, chosen for their established rigor and applicability to digital education. These criteria were adapted for this study to align with the DigCompEdu framework, ensuring relevance to the specific context of VET educator digital competency assessment.

Data Analysis

To gauge the effectiveness of e-learning platforms in fostering digital competencies among VET educators, we embarked on a comprehensive analysis utilizing our custom-built rubric. Designed to assess various dimensions of each platform, the rubric delves into elements such as course organization, learning targets, assessment methods, educational materials, learner involvement, technology integration, support features, and accessibility. In the following sections, we offer a condensed overview of the main insights gleaned from the evaluation of the selected platforms, shedding light on their adherence to the rubric criteria.

XR-Skills platform

Course Design and Navigation: The platform offers basic navigation features but lacks comprehensive instructions and clear statements of purpose, policies, and contact information, potentially causing confusion for learners.

Educational Content and Learning Objectives: The platform lacks clearly defined learning objectives, expected outcomes, and alignment with professional digital competences for teachers, indicating insufficient planning and preparation.

Assessment and Progress Tracking: Limited assessment options are available, with certificates issued without evaluating learners' progress. The absence of varied assessment methods hinders effective progress tracking.

Engagement and Interaction: Opportunities for learner interaction and collaboration are minimal, impacting the overall engagement and active learning experience.

Course Technology: The platform lacks integrated tools or technologies to support learning objectives, hindering effective use of technology for educational purposes.

Support Services: Clear instructions and descriptions of available technical support are missing, potentially impeding learners' access to necessary assistance and resources.

Accessibility and Usability: While navigation and readability are satisfactory, the platform lacks alternative access formats and multimedia support, limiting accessibility for diverse learners.

Summary of XR-Skills features. Overall, the XR-Skills platform exhibits strengths in design and usability but requires significant improvements in defining learning objectives, assessment methods, promoting engagement, integrating technology, providing support services, and enhancing accessibility.

DigiREACT platform

Course Design and Structure: DigiREACT excels in presenting clear course objectives and structure, but lacks detailed policies, prerequisites, and clear communication channels with course leaders. The absence of instructions in Greek may pose challenges for non-English speakers.

Learning Objectives: While providing well-defined and measurable objectives, DigiREACT could improve alignment with learner perspectives and explicit linkage to course activities. There's a need to directly reference the DigCompEdu framework.

Assessment Strategies: DigiREACT offers various assessment tools but lacks specific criteria and feedback, potentially causing confusion about course completion requirements.

Educational Materials: The platform's educational materials effectively contribute to learning objectives, yet there's ambiguity in distinguishing mandatory and optional materials, and incomplete usage instructions may pose challenges for learners.

Learning Activities: DigiREACT includes diverse learning activities that promote interaction and active learning, supporting the achievement of learning objectives effectively.

Course Technology: While engaging learners through interactive and gamified activities, DigiREACT fails to provide privacy policy links for all external tools, raising concerns about data security and privacy.

Support Services: While offering clear instructions for accessing educational resources, DigiREACT lacks technical support and comprehensive referrals to external resources, potentially hindering learner success.

Accessibility and Usability: Although designed for ease of navigation and readability, the platform lacks sufficient accommodation for learners with disabilities and accessibility information for required technologies. Additionally, course guides are only available in English.

Summary of DigiREACT features. Overall, DigiREACT provides a comprehensive and interactive learning environment with clear course objectives, diverse learning activities, and effective use of technology. While the platform excels in presenting course structure and educational materials, improvements are needed in providing detailed policies, clearer assessment criteria, better support services, and enhanced accessibility for learners with disabilities. Addressing these areas will ensure a more inclusive and supportive learning experience for all users.

The GROOVE Platform

Course Design and Learner Support: The GROOVE platform effectively introduces the structure and purpose of each chapter and includes a useful digital action planning function. However, it lacks clear instructions for starting the course and information on how learners can contact support staff, limiting its user-friendliness and effectiveness.

Learning Objectives: While the platform clearly articulates learning objectives at the chapter level, it needs to clarify course-level objectives and explicitly link these objectives to course activities to enhance the overall learning experience.

Assessment Strategies: The platform provides tools for monitoring learner progress and knowledge assessment through tests. However, it falls short in detailing learning objectives and competences, lacks specific assessment criteria, and offers a limited variety of assessment tools, reducing the effectiveness of the assessments.

Educational Materials: The GROOVE platform aligns learning materials with the stated objectives but needs improvement in explaining the purpose and use of materials, distinguishing between mandatory and optional content, and ensuring that teaching materials are properly referenced for transparency and reliability.

Learning Activities: The platform promotes learning objectives and active learning but lacks sufficient opportunities for interaction and engagement, which could enhance the overall learning experience and effectiveness.

Course Technology: The platform ensures access to required technologies and promotes active learning. However, it needs to diversify and update the technologies used and provide access to privacy policies to improve technological support and the overall quality of the learning experience.

Support Services: The GROOVE platform does not provide clear guidance on accessing technical support or collaboration resources, limiting learners' ability to receive necessary assistance and support, potentially impacting their learning outcomes.

Accessibility and Usability: While the platform is easy to navigate and offers good readability, it lacks alternative access forms and multimedia elements that enhance usability and accessibility for all learners.

Summary of GROOVE features. The GROOVE platform offers a structured and navigable learning environment with clear chapter-level objectives and useful digital action planning. However, it requires significant improvements in course-level objective clarity, assessment strategies, learner support services, technology use, and accessibility to provide a more comprehensive and effective learning experience.

Discussion

The evaluation process meticulously scrutinized eLearning platforms, utilizing a rubric composed of predefined criteria. These criteria encompassed various facets, including course design clarity, delineation of learning objectives, assessment methodologies, supportive learning materials, interactivity features, course technology, availability of support services, and accessibility and usability considerations. Through this systematic approach, each platform underwent comprehensive assessment, enabling an objective comparison.

Implications of the Findings

The findings unearthed valuable insights into the strengths and weaknesses of the evaluated eLearning platforms concerning the augmentation of digital competencies among VET educators. These insights serve as pivotal pillars for informed decision-making regarding the selection of platforms conducive to achieving pedagogical objectives and addressing learner needs. Furthermore, the identification of specific improvement areas presents opportunities for refining eLearning platforms to better align with the evolving demands of VET education.

Integration with Research Objectives

The discussion of evaluation findings harmonizes seamlessly with the research objectives, which aimed to gauge the aptness of eLearning platforms in bolstering digital competencies among VET educators. By meticulously examining the extent to which the predefined criteria were met by each platform, this study contributes significantly to the broader discourse on effective strategies for infusing technology into vocational education and training.

Future Directions

Drawing upon the insights gleaned from this evaluation, future research endeavors could delve into innovative methodologies aimed at addressing the identified limitations of eLearning platforms. Moreover, continual monitoring and evaluation efforts are imperative to ensure the sustained efficacy and relevance of these platforms in catalyzing the digital transformation of VET teaching practices.

Conclusion

The evaluation of the e-learning platforms using the developed rubric provided valuable information on their effectiveness in enhancing the digital competences of VET teachers. Through a systematic evaluation of various criteria, including clarity of course design, description of learning objectives, assessment strategies and accessibility, among others, the strengths and weaknesses of each platform were identified, contributing to a deeper understanding of their suitability for VET.

Therefore, it was shown that the rubric developed offers the following benefits to VET teachers:

a) Objective Evaluation: This benefit underscores the importance of having clear evaluation criteria, which enables educators to assess e-learning platforms objectively and consistently. Objective evaluation is crucial for ensuring fairness and accuracy in the assessment process.

b) Systematic Analysis: Highlighting the rubric's role in facilitating systematic analysis emphasizes its utility in thoroughly examining various aspects of e-learning platforms. This structured approach helps educators identify strengths and weaknesses more effectively.

c) Transparency and Reliability: Ensuring transparency and reliability in the assessment process is essential for establishing trust and credibility. By utilizing a predefined rubric, educators can enhance the transparency of their evaluations, leading to more reliable outcomes.

d) Professional Development: The rubric not only serves as a tool for evaluation but also offers a valuable opportunity for professional development. Engaging with the rubric enhances educators' understanding of quality criteria and fosters continuous improvement in their teaching practices related to e-learning platforms.

Overall, these benefits demonstrate how the rubric contributes to the enhancement of VET educators' skills and practices in evaluating and selecting e-learning platforms, ultimately improving the quality of digital education delivery.

Recommendations for VET Teachers

Based on the findings from the data analysis and the use of the rubric, the following recommendations are proposed for VET teachers regarding the selection of e-learning platforms aimed at enhancing their digital competences:

Clear Course Design: Choose an e-learning platform that provides clear instructions for starting and accessing different elements of the course.

Description of Learning Objectives: Select platforms that allow for a defined and measurable description of learning objectives and competences.

Assessment Strategies: Opt for platforms that provide specific and descriptive assessment criteria and offer multiple opportunities to monitor learners' progress.

Materials Supporting Learning Objectives: Choose platforms with a variety of educational materials that are clearly linked to the learning objectives and are easily accessible.

Supporting Interaction: Select platforms that promote active participation and interaction of learners through engaging activities and tasks.

Technology Support: Ensure the platform supports the effective use of technology to achieve learning objectives and provides easy access to it.

Access to Support Services: Choose platforms that provide clear guidance and information on available support services.

Accessibility and Usability: Opt for platforms that are user-friendly, easy to navigate, and provide alternative means of access for all learners.

Implications for Practice

In today's rapidly evolving educational landscape, the integration of technology into vocational education and training represents a pivotal opportunity for institutions to enhance teaching effectiveness and elevate learner outcomes. The comprehensive evaluation conducted in this study offers invaluable insights into the strengths and weaknesses of various eLearning platforms, providing VET institutions with a roadmap for selecting the most suitable platforms tailored to their unique needs and objectives. By leveraging these findings, institutions can make informed decisions that align with their pedagogical goals, resource constraints, and technological infrastructure, thereby maximizing the impact of digital tools in the learning environment.

Furthermore, the implications extend beyond platform selection to encompass broader considerations regarding digital integration and professional development. As VET institutions embrace eLearning platforms that align with the DigCompEdu standards, they not only enhance the digital competences of their educators but also cultivate a culture of innovation and adaptability. Through targeted training initiatives and ongoing support mechanisms, institutions can empower educators to harness the full potential of technology in their teaching practices, facilitating engaging and interactive learning experiences for students.

Moreover, the implications extend to policy and strategic planning within the VET sector. By recognizing the significance of digital competence development and investing in infrastructure and resources to support eLearning initiatives, policymakers can position VET institutions for long-term success in a digitally driven society. By fostering collaboration among stakeholders, sharing best practices, and incentivizing innovation, policymakers can create an ecosystem conducive to continuous improvement and excellence in vocational education and training.

In conclusion, the implications drawn from this study underscore the transformative potential of technology in VET settings and highlight the critical role of informed decision-making in leveraging digital tools for educational enhancement. By embracing these implications, VET institutions can pave the way for a future where technology serves as a catalyst for empowering learners, enriching teaching practices, and driving positive outcomes in vocational education and training.

Closing Remarks

In conclusion, this study has shed light on the critical role of informed decision-making and continuous improvement in leveraging technology for educational enhancement within vocational education and training (VET) settings. By evaluating eLearning platforms through a comprehensive rubric and providing recommendations tailored to VET teachers, we have taken a significant step towards empowering educators in their digital competence development journey.

The findings of this research underscore the importance of aligning eLearning platforms with pedagogical goals and learner needs, emphasizing clear course design, robust assessment strategies, and supportive technology integration. Through systematic evaluation and thoughtful consideration of these recommendations, VET institutions can foster engaging and inclusive digital learning environments conducive to improved teaching effectiveness and enhanced learner outcomes.

As we move forward, it is imperative to recognize the ongoing evolution of technology and its impact on educational practices. Therefore, embracing a mindset of continuous improvement and adaptation is paramount. By staying abreast of emerging trends and best practices in eLearning, VET educators can remain at the forefront of pedagogical innovation, ensuring the delivery of high-quality education that meets the demands of the modern workforce.

In essence, this study serves as a testament to the transformative potential of technology in VET settings when coupled with informed decision-making and a commitment to excellence. By harnessing the insights gleaned from this research and embracing a culture of continuous improvement, we can pave the way for a future where digital innovation enriches the teaching and learning experience for all stakeholders in vocational education and training.

References

DigiREACT. (2022). expeRience brEwing Assistant for voCational Training: the ultimate e-VETtrainer guide for DIGItal transformation. European Commission Project ID: 2021-1-DE02-KA220-VET-000032967. Retrieved from https://www.digireact-project.eu/

European Commission, Directorate-General for Education, Youth, Sport and Culture. (2017). *Erasmus+ project results platform*. Publications Office of the European Union. Retrieved from https://data.europa.eu/doi/10.2766/80295

GROOVE. (2021). DiGital tRansfOrmatiOn of the Vet sEctor. European Commission Project ID: 2021-1-CY01-KA220-VET-000033254. Retrieved from https://grooveproject.eu/

Quality Matters. (2015). *Continuing Education and Professional Development (CPE) Rubric*. Retrieved from https://www.qualitymatters.org/qa-resources/rubric-standards/cpe-rubric

Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu. Y. Punie (Ed.),* EUR 28775 EN. Publications Office of the European Union. DOI:10.2760/159770, JRC107466

UNESCO-UNEVOC. (2022). *Digital Transformation in TVET*. Retrieved from https://unevoc.unesco.org/home/Digital+Transformation+in+TVET

UNICEF Regional Office for Europe and Central Asia (EACARO). (2022). *Educators' Digital Competence Framework*. Retrieved from https://www.unicef.org/eca/reports/educators-digital-competence-framework

XR_Skill. (2023). Enhancing soft skills through extended Reality in the post-COVID era. European Commission Project ID: 2021-1-SE01-KA220-VET-000030106. Retrieved from xrskill.infoproject.eu

Author's Note

This paper is derived from the author's undergraduate thesis. The research was conducted as part of the requirements for the undergraduate degree program, and the findings and methodologies reflect the academic objectives of that program.

Author Details

Georgios Karavassilis
School of Pedagogical and Technological Education (ASPAITE)
GREECE
gmkaravasilis@gmail.com

Appendix 1

The rubric is based on the Quality Matters Non-annotated Standards from the QM Continuing and Professional Education Rubric, Second Edition, including eight General Standards. It has been adjusted to meet the needs of VET educators to quickly and effectively evaluate if a course developed on an eLearning platform meets their needs for the development of student digital competencies based on the DigCompEdu framework that organizes digital competences into 22 competencies across six key areas.

General Standards and Criteria		Score		
General Standard	**Criteria**	**1**	**2**	**3**
General Standard 1: Course Overview and Introduction **The overall design of the course is made clear to the learner at the beginning of the course.**	1.1 Instructions make clear how to get started and where to find various course components.			
	1.2 Learners are introduced to the purpose and structure of the course.			
	1.3 Course, institutional, or organizational policies with which the learner is expected to comply are clearly stated, or a link to current policies is provided.			
	1.4 Minimum technology requirements are clearly stated, and instructions for use are provided.			
	1.5 Prerequisite knowledge in the discipline and/or any required competencies are clearly stated.			
	1.6 Minimum technical skills expected of the learner are clearly stated.			
	1.7 The course includes information on who the trainee can contact with questions and how to contact that person.			
General Standard 2: Learning Objectives (Competencies) **Learning objectives or competencies describe what learners will be able to do upon completion of the course.**	2.1 The course learning objectives, or course/program competencies, describe outcomes that are measurable.			
	2.2 The module/unit learning objectives or competencies describe outcomes that are measurable and consistent with the course-level objectives or competencies.			
	2.3 All learning objectives or competencies are stated clearly and written from the learner's perspective.			
	2.4 The relationship between learning objectives or competencies and course activities is clearly stated.			

General Standards and Criteria		Score		
General Standard	**Criteria**	**1**	**2**	**3**
	2.5 The learning objectives or competencies are suited to the purpose or level of the course.			
	2.6 The learning objectives address at least one of the 22 professional digital competences for teachers.			
	2.7 Indicates which teachers' professional digital competences are covered by the course.			
General Standard 3: Assessment and Measurement **Assessment strategies are integral to the learning process and are designed to evaluate learner progress in achieving the stated learning objectives or mastering the competencies.**	3.1 The assessments measure the stated learning objectives or competencies.			
	3.2 Course information specifies how successful completion of the course will be recognized.			
	3.3 Specific and descriptive criteria are provided for the evaluation of learners' work and are tied to the course policy for determination of successful course completion.			
	3.4 The assessment instruments selected are sequenced, varied, and suited to the learner work being assessed.			
	3.5 The course provides learners with multiple opportunities to track their learning progress.			
General Standard 4: Instructional Materials **Instructional materials enable learners to achieve stated learning objectives or competencies.**	4.1 The instructional materials contribute to the achievement of the stated course and module/unit learning objectives or competencies.			
	4.2 Both the purpose of instructional materials and how the materials are to be used for learning activities are clearly explained.			
	4.3 All instructional materials used in the course are appropriately cited.			
	4.4 The instructional materials are current.			
	4.5 A variety of instructional materials is used in the course.			
	4.6 The distinction between required and optional materials is clearly explained.			
General Standard 5: Course Activities and Learner Interaction **Course activities facilitate and support learner interaction and engagement.**	5.1 The learning activities promote the achievement of the stated learning objectives or competencies.			
	5.2 Learning activities provide opportunities for interaction that support active learning.			

General Standards and Criteria		Score		
General Standard	**Criteria**	**1**	**2**	**3**
General Standard 6: Course Technology **Course technologies support learners' achievement of course objectives or competencies.**	6.1 The tools used in the course support the learning objectives or competencies.			
	6.2 Course tools promote learner engagement and active learning.			
	6.3 Technologies required in the course are readily obtainable.			
	6.4 The course technologies are current.			
	6.5 Links are provided to privacy policies for all external tools required in the course.			
General Standard 7: Learner Support **The course facilitates learner access to support**	7.1 The course instructions articulate or link to a clear description of the technical support offered and how to obtain it.			
	7.2 Course instructions articulate or link to the institution or organization's accessibility policies and services.			
General Standard 8: Accessibility and Usability **The course design reflects a commitment to accessibility and usability for all learners.**	8.1 Course navigation facilitates ease of use.			
	8.2 Information is provided about accessibility of all technologies required in the course.			
	8.3 The course provides alternative means of access to course materials in formats that meet the needs of diverse learners.			
	8.4 The course design facilitates readability.			
	8.5 Course multimedia facilitate ease of use.			

WOMEN’S RIGHTS NGOS AND ONLINE INFORMATIONAL AND EDUCATIONAL CONTENT: A COMPARATIVE ANALYSIS OF THE NGOs’ WEBSITES IN TURKIYE

Dr. Seyma Esin Erben
Istanbul Gelisim University

Dr. Hazal Koray Alay
Batman University

TURKIYE

Abstract[1]

This study aims to reveal the functions and focuses of the websites of women's rights non-governmental organizations (NGOs) in Turkiye, especially in providing education and educational content. Therefore, it is discussed how much educational information and resources these NGOs offer through their websites. For this purpose, a comparative website analysis has been conducted on the websites of the Sexual Violence Prevention Association (Cinsel Şiddetle Mücadele Derneği), the Flying Broom Women's Communication and Research Association (Uçan Süpürge Kadın İletişim ve Araştırma Derneği), the Purple Roof Women's Shelter Foundation (Mor Çatı Kadın Sığınağı Vakfı), the Women's Platform for Equality (Eşitlik için Kadın Platformu), and the We Will Stop Femicides Platform (Kadın Cinayetlerini Durduracağız Platformu). As a result of this comparative analysis, it is evident that women's rights NGOs address educational content and educate others together with data and reporting. This study contributes to understanding the online activities of NGOs in Turkiye, a country that withdrew its signature from the Istanbul Convention despite all objections from women's organizations.

Author Details

Şeyma Esin Erben
İstanbul Gelişim University
Türkiye
esin.erben@gmail.com

Hazal Koray Alay
Batman University
Türkiye
hazalkoray.alay@batman.edu.tr

[1]The manuscript underwent two reviews by conference reviewers and editors, but the authors requested that only the abstract be included in the proceedings.

FAKE NEWS ANALYSIS: PREDICTIVE CAPABILITIES AND IMPLEMENTATION ON THE WEB WITH NEURAL NETWORKS

Antonis Gantzos
GREECE

Abstract

The aim of this paper is the implementation of a website capable of distinguishing fake from real news. Firstly, the training of two neural networks was needed, one of which got integrated into the application and makes the predictions using the logistic regression classifier algorithm. In order to train both models, a dataset, containing predetermined values, was used. Afterwards, the performances of both models were compared on various metrics, with the most efficient being incorporated into the website. This process was executed after appropriate preprocessing was performed on the dataset. Python programming language was used for each step described in this research.

1. Introduction to Machine Learning Techniques

1.1 Definition of the Problem

Fake news and misinformation have become a constant problem in modern society, influencing people, communities, and even worldwide events. With the rise of digital news outlets and the ease of information dissemination on the internet, the spread of false news has accelerated, leading to widespread misinformation, confusion, and erosion of trust in traditional sources of information. Fake or unreliable news cover a variety of false or misleading information that are created in order to influence the receivers and prompt them to form opinions according to the narrative that is being propagated. A study conducted by the Electronic Cultural Press Center of the University of Loughborough in 2019 (Chadwick & Vaccari, 2019) revealed that 42.8% of individuals who share news admit to disseminating inaccurate or false information knowingly. This paper aims to create a fake news detection system that can easily be used by the general public to validate a news resource, while simultaneously archiving the fake news it detects, creating a "digital library" of false news. The research can be split into three stages:

1. Introduction to neural networks and fundamental concepts of machine learning and analysis of existing studies that cover similar issues.
2. Implementation of a neural network model capable of making predictions based on a given dataset.
3. Integration of the model into a website and analysis of its capabilities.

1.2. Introduction to Machine Learning and Deep Learning

The basic idea of **machine learning** is that algorithms have the ability to dynamically improve their results with each new execution. Machine learning is categorized into two techniques: *supervised learning*, where the algorithm learns a concept from a given model or dataset, and *unsupervised learning*, where the system is tasked with making associations and grouping records that share common characteristics, thus creating a pattern between them. The effectiveness of a machine learning system is directly dependent on the quantity and quality of the data provided as input into the system's algorithm.

Although **deep learning** is considered a sub-category of machine learning, there are certain points that differentiate the two concepts:

- Training a deep learning algorithm requires a significantly larger amount of data than what machine learning algorithms need to understand the problem and make decisions.
- Deep learning algorithms require much more computational power due to the complexity and volume of data needed in order to train them.
- Deep learning algorithms rely on the creation of neural networks in order to make decisions on their own and perform corresponding actions.

1.3. Introduction to Data Classification

Data classification is a fundamental concept in the field of artificial intelligence and machine learning. It involves training a model to classify incoming data into predefined categories or classes based on their features. There are four data classification tasks in machine learning (Brownlee, 2020):

- **Binary Classification:** Binary data classification tasks involve one class representing the normal condition of given data and another class representing the abnormal condition, for example classifying an email account as "non-spam", which would be the normal condition, in contrast with "spam", which would be the abnormal condition. The class for the normal condition is usually labeled as “0”, and for the abnormal as “1”. Binary classification is often implemented with a model that utilizes the Bernoulli probability distribution to make a prediction.

- **Multi-class Classification:** Multi-class classification refers to classification problems that have more than two class labels. Unlike binary classification, it does not have the notion of normal and abnormal outcomes. Instead, each data entry in a set is categorized into one class from a range of classes based on its features.
- **Multi-Label Classification:** This refers to classification tasks where a data entry in a set can belong to more than one class.
- **Imbalanced Classification:** This refers to classification tasks where the number of data entries in each class varies in size, thus creating an imbalance in the data. Examples include fraud or anomaly detection.

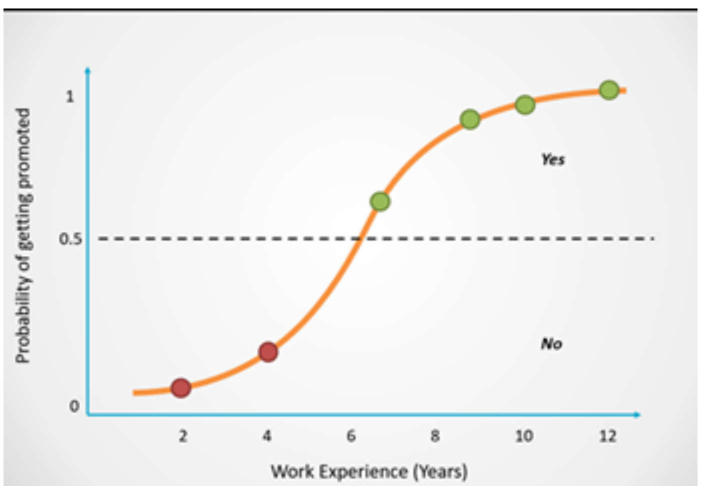
A classification task is handled by implementing a ***classification algorithm***. The most common are Logistic Regression, Support Vector Machines, Decision Trees, K-Nearest Neighbors, and Naïve Bayes (Tan et al., 2018).

1.3.1 Logistic Regression

The basic idea behind logistic regression is to use a prediction function that represents the data of entry x and makes a prediction y using the following formula: $P(y=1|x;w) = 1 / (1 + e^{-z})$, where $z = g(w^T x)$, with w^T defined as a vector containing all parameters w for each x (feature) present in the dataset. The result of the function is the probability that y=1, which holds whenever $g(z) \geq 0$. Otherwise, the record's label is classified as 0 (see Figure 1 below).

Figure 1

Data Normalization using Logistic Regression



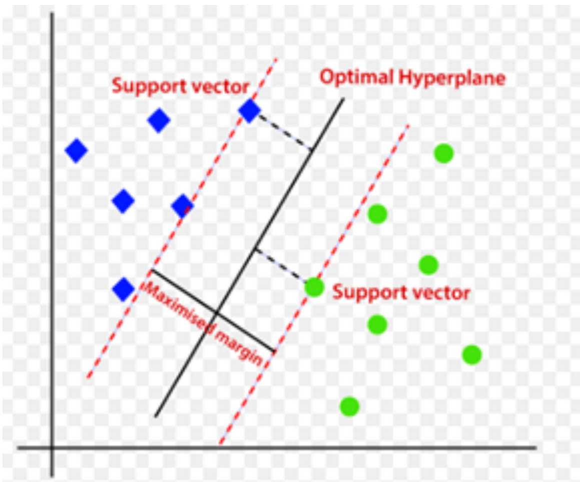
Note. From "*Logistic Regression Explained in 7 Minutes*", by N. Selvaraj, 2022. (https://www.natasshaselvaraj.com/logistic-regression-explained-in-7-minutes/)

1.3.2 Support Vector Machines

The Support Vector Machine algorithm uses the principle of structural risk minimization to set linear or nonlinear decision boundaries in the space between features, ensuring good performance. Furthermore, it provides very strong adaptation capabilities, controlling the model's complexity to ensure good performance without causing overfitting problems (see Figure 2 below):

Figure 2

Data Classification using SVM



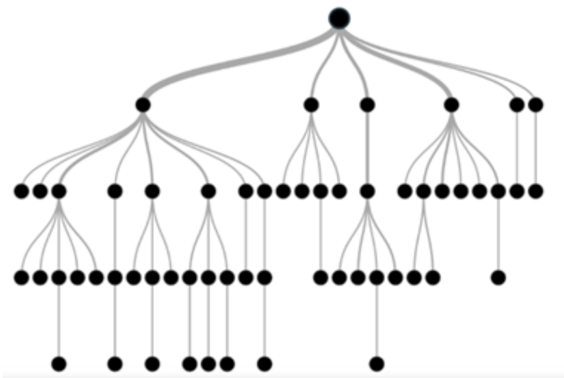
Note. From "*Support Vector Machine Algorithm*" by Javatpoint.com, (n.d.), (https://www.javatpoint.com/machine-learning-support-vector-machine-algorithm)

1.3.3 Decision Tree

The Decision Tree is a non-parametric algorithm used for data classification or regression problems. This means that no assumption about the shapes of the distributions are made, but are approximated by a process of smoothing. It has a hierarchical tree structure consisting of a root node, branches, internal nodes, and leaves. Each node in the tree specifies a test on a data entry, each branch descending from that node corresponds to one of the possible values for that attribute (see Figure 3 below).

Figure 3

Diagram of a Simple Decision Tree



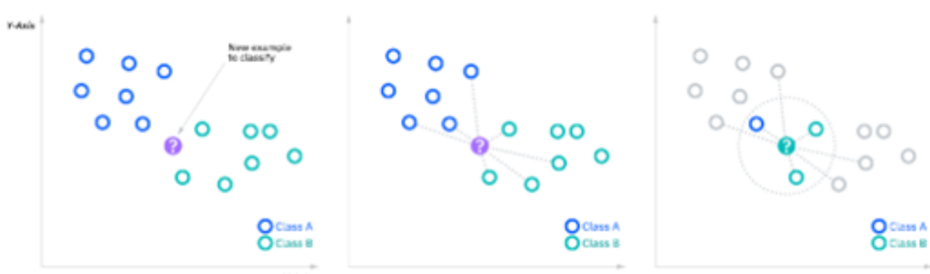
Note. From "Random Forest,GBM(Gradient Boosting Machines)" by C. Kök, 2022 (https://medium.com/@trcahit/random-forest-gbm-gradient-boosting-machines-7cca3badf39b)

1.3.4 K-Nearest Neighbors

K-Nearest Neighbors is a non-parametric algorithm that measures the distance between points to make predictions by identifying the closest "neighbors" of a given point. Working on the assumption that similar points can be found close to each other, the goal of the K-Nearest Neighbors algorithm is to identify the closest "neighbors" of a given data entry and assign a class label to it. The *Euclidean Distance formula* is commonly used to measure the distance of a given point from its neighbors (see Figure 4 below).

Figure 4

K-Nearest Neighbors Algorithm Example



Note. From "*What is the k-nearest neighbors (KNN) algorithm?*", by IBM, (n.d.) (https://www.ibm.com/topics/knn)

1.3.5 Naive Bayes

Based on Bayes' theorem, the Naive Bayes algorithm assumes independence between features and calculates the probability that a given input instance belongs to a specific class.

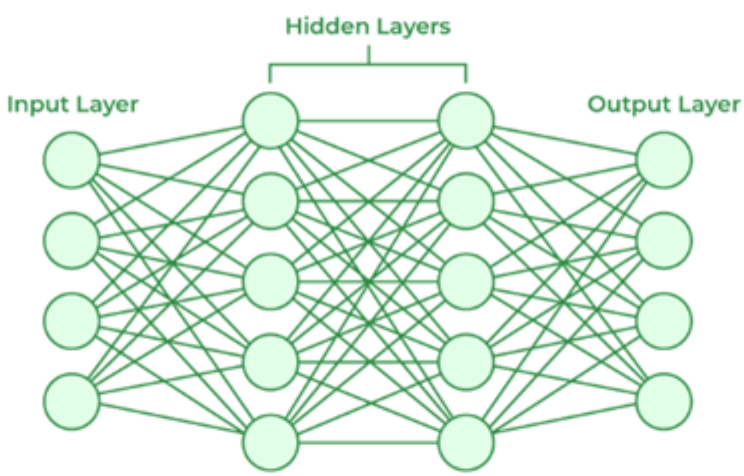
1.4. Introduction to Neural Networks

A **neural network** is a method in artificial intelligence that teaches computers to process data in a manner similar to the human brain. It is a type of deep learning process that uses interconnected nodes (**neurons**) in a layered structure resembling the human brain. This creates an adaptive system that a model can use to learn from its mistakes and continuously improve on its predictions (Amazon Web Services, n.d.). A neural network can be structured into three basic layers:

1. **Input Layer.** Input data enters an artificial neural network through the input layer. The input nodes process, analyze, or categorize the data and pass it to the next layer.
2. **Hidden Layers.** Data is received from an input layer or other hidden layers. Each hidden layer analyzes the output from the previous layer, processes it further, and passes it to the next layer.
3. **Output Layer.** This provides the final outcome of all data processing done by previous layers. It can have a single or multiple nodes, depending on the classification task the neural network is working on. The architecture of a neural network can be seen in Figure 5

Figure 5

Architecture of a Neural Network



Note. From "Building a Basic Neural Network from Scratch: A Step-by-Step Guide", by D. Bhatnagar, 2023, *Medium*, https://bhatnagar91.medium.com/building-a-basic-neural-network-from-scratch-a-step-by-step-guide-7a6f97979ddd/

Having covered the basic ideas behind neural networks, all that remains is to answer the following question: How is a neural network trained? In supervised learning, artificial neural networks are given labeled datasets that provide the correct answer in advance and gradually build knowledge step by step by making repeated predictions on these datasets. Once the network is trained, it begins to make estimates about data it has never processed before.

1.5 Related Research

In related research, the following articles propose various approaches for detecting fake news using a variety of machine learning techniques.

Sanei et al. (2017), have explored ways to increase the efficiency of the KNN algorithm to provide better results for their model's predictions. The algorithm is used to select the best parameters for the nonlinear functions that are most suitable for each feature, with results being generally better compared to those in a similar study conducted Nair and Kashyap (2019), who proposed the use of resampling and interquartile range (IQR) techniques in the data preprocessing steps, which are normalized for better algorithm performance.

Kesarwani et al. (2021) created a fake news detection model based on news headlines, as well as various articles and news frequently appearing on several users' social networks.

Nagashri and Sangeetha (2021) attempted to identify fake news using evaluation metrics techniques and tested many machine learning concepts based on accuracy, precision, recall, and F1 score, concluding that the TFIDF vectorizer should be the most preferred text preprocessing technique. Further reference to the metrics used to measure the performance of a model will be made in section 2 of this paper.

Vijayaraghavan et al. (2020) attempted to define a connection between words and the context in which they appear within the text, as well as how they could be used to categorize a given news article as true or fictional. They used models such as Count Vectorizer to convert texts into numerical representations and investigated which model is capable of more accurately determining the article as real or fake.

2. Fake News Detection System

2.1 Introduction

This section of the paper describes the methodology and steps followed to implement and train a neural network model. Initially, a training dataset was used, to which various natural language processing techniques were applied. Subsequently, two neural network models are created: a linear and a non-linear. The two models were compared based on certain metrics, and the model that produced the greater results was integrated into the website.

2.2 Dataset Description

The dataset used is sourced from the GitHub repository (Lifferth, 2018) and consists of a collection of news articles. Each news article corresponds to a record in the dataset, with the following features:

- **ID:** The record number.
- **Title:** The title of the news article.
- **Author:** The name of the author who wrote the article text.
- **Text:** The text of the news article.

Each record also includes a label, which can take two values: 0 or 1. This value assists in categorizing a news article as true, if the value is “0”, or false, if the value is “1”. The dataset comprises approximately 10,000 records.

For the model implementation, Python was utilized in conjunction with the PyTorch library for creating the neural network. Pandas, Scikit-learn, and NumPy were used for data preprocessing and result evaluation. A general format of the dataset is seen in Figure 6.

Figure 6

A General Format of the Dataset

	id	title	author	text	label
0	0	House Dem Aide: We Didn't Even See Comey's Let...	Darrell Lucus	House Dem Aide: We Didn't Even See Comey's Let...	1
1	1	FLYNN: Hillary Clinton, Big Woman on Campus - ...	Daniel J. Flynn	Ever get the feeling your life circles the rou...	0
2	2	Why the Truth Might Get You Fired	Consortiumnews.com	Why the Truth Might Get You Fired October 29, ...	1
3	3	15 Civilians Killed In Single US Airstrike Hav...	Jessica Purkiss	Videos 15 Civilians Killed In Single US Airstr...	1
4	4	Iranian woman jailed for fictional unpublished...	Howard Portnoy	Print \nAn Iranian woman has been sentenced to...	1

2.3 Data Pre-processing

Due to the natural language from which the texts representing the data are composed, some noise must be removed before data is fed into a neural network. In order to make input data suitable for the algorithms to operate, it undergoes various pre-processing techniques aimed at smoothing the dataset. These techniques are as follows:

- **Removal of duplicate and missing records:** Entries that appear more than once in the dataset and entries that do not provide any information that can be utilized later are removed.

- **Conversion of all letters to lowercase:** This technique aids in uniformity among the dataset's entries and facilitates their processing.
- **Removal of punctuation marks from each entry:** Performed for similar reasons as lower case conversion.
- **Removal of unnecessary words in each entry of the set (Stopwords removal):** Stopwords are essentially words that add value to other words or define a relationship between words. These may include various adjectives, adverbs, prepositions, conjunctions, and pronouns. Since the dataset includes various articles, it is necessary to remove these words before data is provided as input.
- **Use of Count Vectorizer:** The final step in data preprocessing is to convert the text given as input to the model into a vector. Vectorization is a process of converting words in a text to a form that can be read by a machine. Therefore, before being given as input to the model, all texts must be represented as vectors (tensors). Each value of the vector represents the frequency of each word in the text. For performing this conversion, the capabilities of a Count Vectorizer are utilized, which, for a given text, creates an array where each position represents a unique word in the text, and the corresponding value of that position represents the frequency of the word (Jain, 2021).

2.4 Model Implementation

The next step is to implement a model of a neural network, which is observed in Figure 7. This model was implemented based on the architecture of neural networks analyzed in the previous section. The flow can be clearly observed in the image below. In **`__init__()`** function, the 2 layers that will process the input data are initialized. The actual processing is executed in the **`forward()`** function. For the hidden layers, the number hidden neurons that will perform the computations is set as relatively small, considering the simplicity and volume of the data, while the number of features that will be inputted is set as one, as well as the number of features that will be produced as output, since the goal is to have one result for each news article (0 for true news or 1 for fake news).

Figure 7

Neural Network Model

```
class FakeNewsDetectionModelV0(nn.Module):
    def __init__(self, input_size):
        super().__init__()
        #create 2 nn.Linear layers to handle the shapes of our data

        #out features number is selected at random but it has to match the next layer's in features number to prevent shape errors
        self.layer_1=nn.Linear(in_features=input_size, out_features=5)
        self.layer_2=nn.Linear(in_features=5, out_features=1)

    #define a forward() for the forward pass
    def forward(self, x, mask):

        # Apply the mask to ignore certain values
        if mask is not None:
            x = x * mask

        x = self.layer_1(x)
        x = self.layer_2(x)
        return x
```

A similar process will be followed for the development of the second model, which, unlike the current one that employs a **Linear** approach, utilizes **Non-Linearity** for processing. However, before continuing with the training of both models, it is necessary to clarify the process followed by each of the two approaches mentioned, as well as their differences.

2.5 Linearity vs Non-Linearity

There are two types of neural network models: linear and non-linear.

2.5.1 Linearity

In many cases, linearity is the simplest and most effective approach. A linear model, essentially, fits a straight line to the data, allowing it to make predictions based on a linear relationship between the input features and the output variable. For this process, the *linear regression* function is utilized: $y=b0+b1 \cdot x1$, where y is the dependent variable (prediction outcome), $x1$ is the independent variable or feature, $b0$ is the intercept of y with the y-axis (constant), and finally $b1$ is the slope coefficient.

2.5.2 Non-Linearity

Non-linear neural network models can take many forms, from polynomial models that fit curves to the data, to neural networks that can learn complex patterns in high-dimensional data. Non-Linear models are often more powerful their Linear counterpart, because they can recognize more complex relationships between variables. In a classification problem, non-linear models can identify more complex than linear decision boundaries that define different classes. However, they may be more challenging to use than linear models, as they usually require much more training data and computational power to achieve good results (Zarra, 2023).

2.6 Training the Models

The next step after preprocessing the data is implementing the training process. A **train_test_split** method is used to split the dataset into two parts. It is defined that 80% of the records of the dataset will be used for training the algorithms, and the remaining 20% will constitute the test sample size. All columns of the dataset are concatenated, forming a unified column, and the data is then split and passed to the Count Vectorizer.

For training a neural network model, the following concepts need to be introduced and implemented (Patil, 2023):

- **Loss Function**: Also known as a cost function, a loss function is used to measure the accuracy of a model's predictions. It calculates the difference between the predicted output and the actual output for each training sample. The goal of the model is to minimize the loss function by the end of training. The smaller the loss function, the better and more accurate the model's parameter set will be in producing predictions.
- **Optimizer**: The optimizer adjusts the model's parameters to gradually minimize the loss function. It's worth noting that optimizers can also adjust various hyperparameters, such as the learning rate, momentum, and others. The main optimizers include **Gradient Descent (GD)**, **Stochastic Gradient Descent (SGD)**, and **Adaptive Moment Estimation (Adam)**. In this particular study, it was determined that the Stochastic Gradient Descent optimizer was better suited for training the models.

The process of training the models involves the following steps:

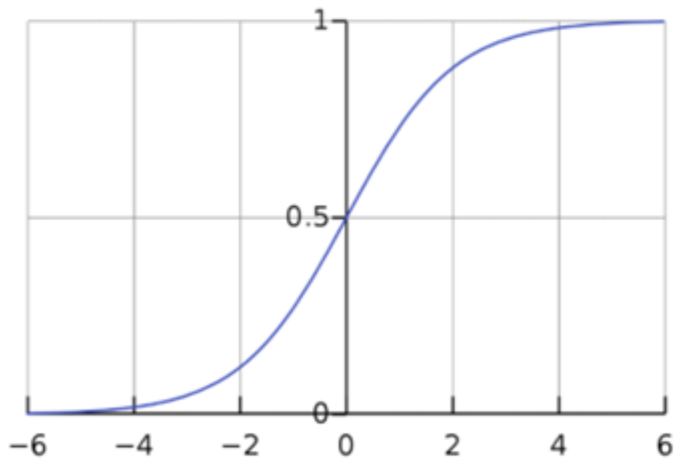
- Input data is passed through the **forward()** function for processing, done by the hidden layers of the network, and the model makes a prediction on it.
- The loss function is computed, estimating how close the model's prediction was to the actual label of the data. The desired output is the gradual minimization of loss function, which indicates good performance.
- The Stochastic Gradient Descent (SGD) algorithm is used to improve the model's parameters, so that the next prediction is more accurate than the previous one in order to make the loss function decrease.
- The process is repeated for a certain number of *epochs*, providing the models with enough opportunities to learn from their mistakes and improve their performance. The goal is for the loss function of each model to reach as close to zero as possible.

Each iteration recalculates the evaluation metrics of the models, which will be discussed in more detail below.

It's also worth noting the process of converting the model's output values into the desired output values, namely “0” or “1”. The values output by the model are called **logits**, and they are the values generated by a neural network before applying an activation function. They are the non-normalized probabilities of a data entry to belong to a certain class. Converting logits into probabilities makes it easier to understand the final output of the neural network for each prediction. The activation function chosen for this conversion is the **sigmoid function,** which can be seen in Figure 8 below. As shown in the diagram below, this function, after converting logits into probabilities, applies the following rule: If the probability is greater than or equal to 0.5, then the output value is 1; otherwise, the output value is 0. Therefore, the output given from both models is the probability of a news item being fake.

Figure 8

Sigmoid Function



Note. From “Sigmoid function”, *Wikipedia* (https://en.wikipedia.org/wiki/Sigmoid_function)

2.7 Evaluation Metrics

After completing the training, it is important to highlight the generated results. The metrics of *Accuracy*, *Precision*, *Recall,* are used to measure the performance of the models (Agrawal, 2024).

2.7.1 Accuracy

Accuracy measures how often the classifier predicts correctly. We can define accuracy as the ratio of the number of correct predictions to the total number of predictions. Correct predictions are those categorized correctly as 0 (**True Positives or TP**) and those categorized correctly as 1 (**True Negatives or TN**), while incorrect predictions are data points that, although their true output value should be 1, the model predicts as 0 (**False Positives or FP**), or vice versa (**False Negatives or FN**). The combination of these four categories constitutes the total predictions of the model. Its formula can be seen in Figure 9 below.

Figure 9

Formula for Calculating the Accuracy Metric

$$\textit{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN}$$

Note. From "Metrics to Evaluate your Classification Model to take the right decisions" by S. K. Agrawal, 2024, *Analytics Vidhya*, https://www.analyticsvidhya.com/blog/2021/07/metrics-to-evaluate-your-classification-model-to-take-the-right-decisions/)

2.7.2 Precision

Precision is used to measure how many of the correctly predicted instances actually turned out to be positive. It is useful in cases when a False Positive is more concerning than a False Negative. Its formula can be seen below.

Figure 10

Formula for Calculating the Precision Metric

$$\text{Precision} = \frac{TP}{TP + FP}$$

Note. From "F1 Score in Machine Learning: Intro & Calculation" by R. Kundu, 2024, *V7labs* (https://www.v7labs.com/blog/f1-score-guide)

2.7.3 Recall

Recall explains how many of the actual positive instances were correctly predicted by the model. Recall is a useful measure in cases when a False Negative is more concerning than a False Positive. Its formula can be seen in Figure 11 below.

Figure 11

Formula for Calculating the Recall metric

$$\text{Recall} = \frac{TP}{TP + FN}$$

Note. From "F1 Score in Machine Learning: Intro & Calculation" by R. Kundu, 2024, *V7labs* (https://www.v7labs.com/blog/f1-score-guide)

2.7.4 F1 Score

An F1 Score is the average of Precision and Recall. It is commonly used when there is a need for a balanced use of both factors in a model evaluation. Its formula can be seen in Figure 12 below.

Figure 12

Formula for calculating the F1 metric

$$\text{F1 Score} = \frac{2}{\frac{1}{\text{Precision}} + \frac{1}{\text{Recall}}} = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

Note. From "F1 Score in Machine Learning: Intro & Calculation" by R. Kundu, 2024, *V7labs* (https://www.v7labs.com/blog/f1-score-guide)

Regarding the dataset in this study, it is observed from Figure 13 that the entries constituting the dataset are almost equally distributed. In such a case where there is no issue of imbalanced classes, the most important metric to consider is Accuracy, as well as the loss function results of each model.

Figure 13

General dataset shape

```
the shape of our data when duplicates are removed is (10800, 5)
1    5417
0    5383
```

2.8 Model Comparison Review

This section compares the performance results of the linear and non-linear models.

2.8.1 Linear Model

The performance results of the linear model can be observed from the following diagrams, beginning with Figure 14.

Figure 14

Performance Measurement Results of the Linear Model over Five Epochs

```
 3%|▌         | 1/30 [00:01<00:36,  1.27s/it]
epoch : 0, training loss: 0.71091, test loss: 0.58467, training accuracy 0.429, testing accuracy
0.666, training precision: 0.43095, training recall: 0.98502, training F1: 0.59958,testing
precision: 0.87302, testing recall: 0.25701, testing F1: 0.39711
 20%|██        | 6/30 [00:05<00:21,  1.10it/s]
epoch : 5, training loss: 0.43858, test loss: 0.42515, training accuracy 0.89075, testing accuracy
0.887, training precision: 0.88005, training recall: 0.86636, training F1: 0.87315,testing
precision: 0.86041, testing recall: 0.87850, testing F1: 0.86936
 37%|███▋      | 11/30 [00:10<00:16,  1.12it/s]
epoch : 10, training loss: 0.36925, test loss: 0.36675, training accuracy 0.9107499999999998,
testing accuracy 0.9010000000000001, training precision: 0.90871, training recall: 0.88306,
training F1: 0.89571,testing precision: 0.87991, testing recall: 0.89019, testing F1: 0.88502
 53%|█████▎    | 16/30 [00:15<00:13,  1.04it/s]
epoch : 15, training loss: 0.32381, test loss: 0.32917, training accuracy 0.925, testing accuracy
0.912, training precision: 0.92789, training recall: 0.89689, training F1: 0.91213,testing
precision: 0.90094, testing recall: 0.89252, testing F1: 0.89671
 70%|███████   | 21/30 [00:19<00:08,  1.12it/s]
epoch : 20, training loss: 0.28916, test loss: 0.30171, training accuracy 0.934, testing accuracy
0.9179999999999999, training precision: 0.93914, training recall: 0.90668, training F1:
0.92263,testing precision: 0.90421, testing recall: 0.90421, testing F1: 0.90421
 87%|████████▋ | 26/30 [00:23<00:03,  1.11it/s]
epoch : 25, training loss: 0.26075, test loss: 0.28024, training accuracy 0.9395, testing accuracy
0.924, training precision: 0.94411, training recall: 0.91475, training F1: 0.92920,testing
precision: 0.91315, testing recall: 0.90888, testing F1: 0.91101
100%|██████████| 30/30 [00:27<00:00,  1.07it/s]
total training time is 28.001 seconds
```

It is observed that both in the training data and the test data, the loss function steadily decreases as the model learns from its previous predictions, while accuracy reaches nearly 95% correct predictions with the other metrics following closely behind with slightly lower percentages. Additionally, it is considered positive that the measurement results in the test data do not differ much from those in the training data, as this indicates that the classifier is not overfitting the training data to the point where it can only make predictions on them and no other dataset that it has no prior knowledge on, as seen in Figures 15 and 16 below.

Figure 15

Diagrammatic Representation of Linear Model Results

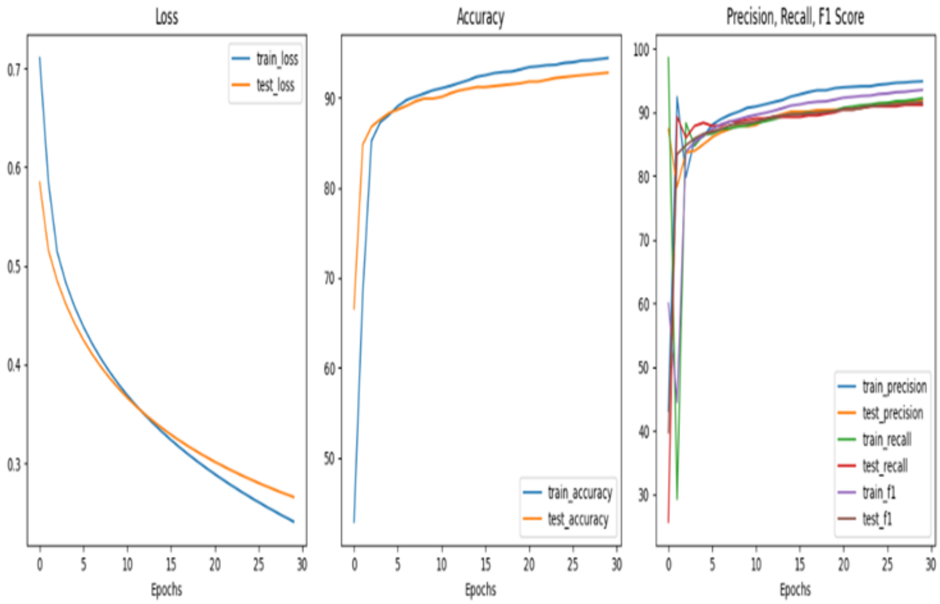
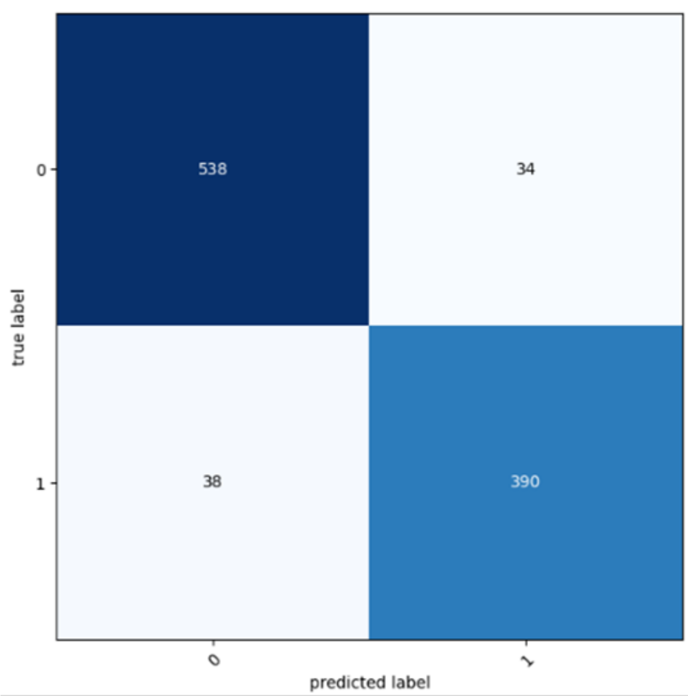


Figure 16

Accuracy Visualization of Linear Model Results using Confusion Matrix

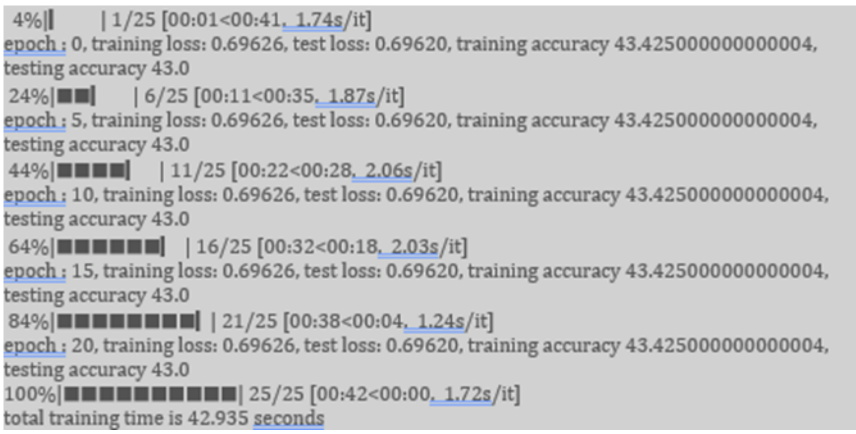


2.8.2 Non-Linear Model

The performance results of the non-linear model can be observed from Figures 17 and 18. It is observed that both in the training data and the test data, the loss function remains steady throughout the model training process, as does the prediction accuracy, with a percentage of approximately 43%. Since it performs binary classification, this percentage is worse than even a random guess.

Figure 17

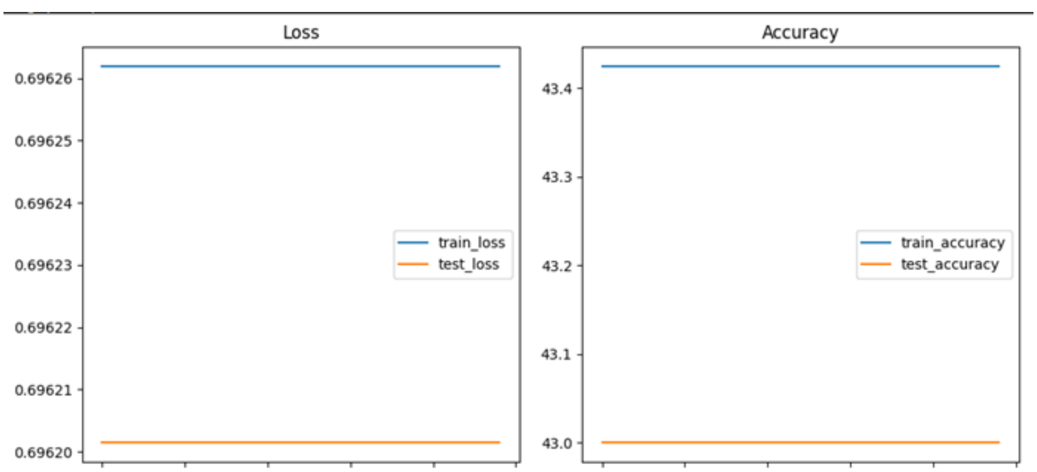
Results of Non-linear Model Performance Measurements per Five Seasons



```
 4%|▌        | 1/25 [00:01<00:41,  1.74s/it]
epoch : 0, training loss: 0.69626, test loss: 0.69620, training accuracy 43.425000000000004,
testing accuracy 43.0
 24%|██       | 6/25 [00:11<00:35,  1.87s/it]
epoch : 5, training loss: 0.69626, test loss: 0.69620, training accuracy 43.425000000000004,
testing accuracy 43.0
 44%|████     | 11/25 [00:22<00:28,  2.06s/it]
epoch : 10, training loss: 0.69626, test loss: 0.69620, training accuracy 43.425000000000004,
testing accuracy 43.0
 64%|██████▌  | 16/25 [00:32<00:18,  2.03s/it]
epoch : 15, training loss: 0.69626, test loss: 0.69620, training accuracy 43.425000000000004,
testing accuracy 43.0
 84%|████████▍| 21/25 [00:38<00:04,  1.24s/it]
epoch : 20, training loss: 0.69626, test loss: 0.69620, training accuracy 43.425000000000004,
testing accuracy 43.0
100%|██████████| 25/25 [00:42<00:00,  1.72s/it]
total training time is 42.935 seconds
```

Figure 18

Diagrammatic Representation of Non-linear Model Results



It is concluded from the superior performance of the linear model, as documented above, that the linear model will ultimately be integrated into the website. Further analysis will follow in the next section to showcase it in more detail.

3. Fake News Detection Application

3.1 Introduction

In the previous section, the methodology for creating and training a neural network model to make predictions was discussed. In this section, the focus of the study will be the implementation and functionalities of a website that integrates the aforementioned model. This website allows users to make predictions and effectively verify the validity of the information they consume. These predictions are stored in a database, which functions as a "digital fake news repository," providing a dataset that can be utilized by anyone conducting a similar research.

3.2 Application technologies

- **React.js | Frontend framework:** Used on all application pages related to the User Interface for user interaction with the application and its functionalities.
- **Python Flask | Backend framework:** Used to create the server and for the interaction of the website with the database.
- **MySQL Database | Relational Database**

3.3 Database Analysis:

The database consists of a single table, which includes the following fields:

- **ID**: Unique attribute of each record in the database
- **Article**: Text describing a news article
- **Fake Probability**: Probability that the news article should be considered false information
- **Label**: Takes only 2 values, "0" or "1", depending on whether a news source is true or false.

3.4 Application Functionalities

The website performs three basic functions: News Prediction, Display of Fake News, and Database Data Export.

3.4.1 News Prediction

News prediction is the most basic function of the application. Since the model has been integrated into the website, a user interface is implemented for users to utilize its prediction capabilities. A text area is created where the user enters the text of an article they want to verify, and by pressing the Predict button on the left, the server response appears, indicating whether the news is reliable or not, along with the probability of it being fake news. It is noted here that since news labeled “0” is defined as true and news labeled “1” is defined as false, the closer the probability received by the user is to 1, the more likely it is that the article should be considered false information. Additionally, by pressing the second button on the right, brief instructions on the application's functionality are provided, as well as contact information to enable users to provide feedback for possible future improvements. An example prediction result can be seen in Figure 19.

Figure 19

Prediction Results

3.4.2 Display of Fake News Database

After each prediction, the news article provided by the user is inserted into the table analysed in the previous section, provided that the news has not been previously entered, ensuring each record is unique. The probability of the news being fake, as well as its label, is also stored. The table, which is seen in Figure 20, is presented on the website using the React framework. The collection of news articles is organized into table pages, using a custom paginator. Additionally, a search filter is provided so that users can research specific news articles.

Figure 20

Data Display in Table

Article	Label
trump is president	1
why the truth might get you fired truth might get fired october 29 2016 te...	1
15 civilians killed in single us airstrike have been identified videos 15 civi...	1
benoît hamon wins french socialist partys presidential nomination the ne...	0
putin is the president	1
obamas organizing for action partners with soroslinked indivisible to disr...	0
jackie mason hollywood would love trump if he bombed north korea over...	0

<< < 1 of 1 > >> Go to Page 1 Page Size 10

3.4.3 Database Data Export

Finally, the website allows the user to export the stored data from the database, with the aim of creating a new dataset that can be used in similar studies. This functionality of the website is activated by pressing the button shown below. The result is presented in Figures 21 and 22; the first 7 data rows in Figure 21 correspond to the seven articles in Figure 20.

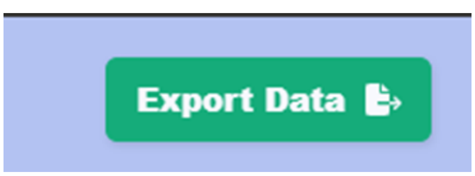
Figure 21

Export Results

	A	B	C	D
1	article	fake_prok	label	
2	trump is p	0.54	1	
3	why the tr	0.99	1	
4	15 civilian	0.93	1	
5	benoî°t h	0	0	
6	putin is th	0.52	1	
7	obamas oı	0.06	0	
8	jackie mas	0.38	0	
9				
10				

Figure 22

Export button



3. Conclusion

This paper focuses on detecting fake news on the internet using machine learning. A neural network, implementing binary classification on data, was developed, labeling reliable information sources with “0” and unreliable sources with “1”.

From the literature review, it was found that the best approach to the problem is binary classification. During the implementation methodology, two neural network models were created: one linear and one non-linear. After preprocessing the input data, both models underwent the exact same training process. Their performance was compared under the same conditions, using metrics such as prediction accuracy and recall. The linear model outperformed the non-linear one and was integrated into the website to allow users to check their information sources as effectively as possible.

The study concludes that, although the non-linear approach is usually considered to produce better results for applications dealing with simpler datasets with less complexity and fewer dimensions, the linear approach is more likely the best solution due to the utilization of Linear Regression, which is more effective for datasets with a smaller number of dimensions.

References

Agrawal, S. K. (2024, February). Metrics to evaluate your classification model to take the right decisions. *Analytics Vidhya*. https://www.analyticsvidhya.com/blog/2021/07/metrics-to-evaluate-your-classification-model-to-take-the-right-decisions/

Amazon Web Services. (n.d.). *What is a neural network?* https://aws.amazon.com/what-is/neural-network/

Bhatnagar, D. (2023). Building a Basic Neural Network from Scratch: A Step-by-Step Guide. *Medium.* https://bhatnagar91.medium.com/building-a-basic-neural-network-from-scratch-a-step-by-step-guide-7a6f97979ddd/

Brownlee, J. (2020, November). *4 types of classification tasks in machine learning*. *Machine Learning Mastery*. https://machinelearningmastery.com/types-of-classification-in-machine-learning/

Chadwick, A., & Vaccari, C. (2019). *News sharing on UK social media: Misinformation, disinformation, and correction survey report*. Loughborough University. Report. https://hdl.handle.net/2134/37720

IBM. (n.d.). *What is the k-nearest neighbors (KNN) algorithm?* https://www.ibm.com/topics/knn

Jain, P. (2021, May). Basics of count vectorizer. *Towards Data Science*. https://towardsdatascience.com/basics-of-countvectorizer-e26677900f9c

Javatpoint. (n.d.). *Support vector machine algorithm.* https://www.javatpoint.com/machine-learning-support-vector-machine-algorithm)

Kesarwani, A., Chauhan, S. S., Nair, A. R., & Verma, G. (2021). Supervised machine learning algorithms for fake news detection. In *Advances in Communication and Computational Technology: Select Proceedings of ICACCT 2019* (pp. 767-778). Springer Singapore. https://doi.org/10.1007/978-981-15-5341-7_58

Kök, C. (2022). Random Forest,GBM(Gradient Boosting Machines). https://medium.com/@trcahit/random-forest-gbm-gradient-boosting-machines-7cca3badf39b

Kundu, R. (2024). F1 Score in Machine Learning: Intro & Calculation. *V7labs.* https://www.v7labs.com/blog/f1-score-guide

Lifferth, W. (2018). Fake News. Kaggle. https://kaggle.com/competitions/fake-news

Nagashri, K., & Sangeetha, J. (2021). Fake news detection using Passive-Aggressive Classifier and other machine learning algorithms. In S.M. Thampi, E. Gelenbe, M. Atiquzzaman, V. Chaudhary, & KC Li, (Eds.) *Advances in computing and network communications: Lecture notes in electrical engineering, 736*. (pp. 221-233). Springer, Singapore. https://doi.org/10.1007/978-981-33-6987-0_19

Nair, P., & Kashyap, I. (2019). Hybrid pre-processing technique for handling imbalanced data and detecting outliers for KNN classifier. In *2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon)* (pp. 460-464). IEEE. doi: 10.1109/COMITCon.2019.8862250

Patil, S. U. (2023, January). Loss functions and optimizers in ML models. *Medium*. https://medium.com/geekculture/loss-functions-and-optimizers-in-ml-models-b125871ff0dc

Sanei, F., Harifi, A., & Golzari, S. (2017). Improving the precision of KNN classifier using nonlinear weighting method based on the spline interpolation. In *2017 7th International Conference on Computer and Knowledge Engineering (ICCKE)* (pp. 289-292). IEEE. doi: 10.1109/ICCKE.2017.8167893

Selvaraj, N. (2022). *Logistic Regression Explained in 7 Minutes*. https://www.natasshaselvaraj.com/logistic-regression-explained-in-7-minutes/)

Tan, P.-N., Steinbach, M., Karpatne, A., & Kumar, V. (2018). *Introduction to data mining* (2nd ed., pp. 147-174). Pearson.

Vijayaraghavan, S., Wang, Y., Guo, Z., Voong, J., Xu, W., Nasseri, A., Cai, J., Li, L., Vuong, K., & Wadhwa, E. (2020). Fake news detection with different models. *arXiv preprint arXiv:2003.04978*. Cornell University. https://doi.org/10.48550/arXiv.2003.04978

Zarra, R. (2023, March). Machine learning: Linearity vs non-linearity. *LinkedIn*. https://www.linkedin.com/pulse/machine-learning-linearity-vs-nonlinearity-reday-zarra/

Author Details

Antonis Gantzos
GREECE
antonisgantzos@gmail.com

NEWS DIGRESSION AND POLITICAL POLARIZATION IN THE UNITED STATES

Yianni Varonis
Political and Communications Consultant
U.S.A.

Abstract

Political polarization in the United States has grown substantially in recent decades, fueled by both social and political factors. Among these, changes in media structures and the decline in journalistic integrity have played significant roles. This paper briefly explores the historical evolution of political polarization in the U.S., the rise of biased news media, and the role social media has played in exacerbating polarization yet also creating misperceptions about existing political divides.

The Growth of Political Polarization in the U.S.

The history of the United States' two-party system can be traced back to debates over the Constitution and whether it should be ratified. Federalists who sought a strong central government supported the Constitution while Anti-Federalists who sought a weak central government opposed the Constitution. Though it was ultimately adopted, this schism soon evolved into the "Party Wars" of the 1790s, pitting Federalists versus the new Democratic-Republican Party.

Over the centuries, the names, ideologies, and supporters of American political sects have evolved, but the tradition of two major political parties remains. On the one hand, the two-party system has served as a force against extremist ideology. In pluralistic governments, fringe parties can be seated in government with even a small percentage of the vote. But in a two-party system, party leaders often weed out extreme candidates and policies in order to appeal to a majority of American voters.

This structure, however, has also rendered American politics, at times, a zero-sum game, as each party's success often comes at the direct expense of the other. In 2010, Senate Minority Leader Mitch McConnell—a Republican—infamously said, "The single most important thing" his caucus wanted "to achieve is for [Democratic] President Obama to be a one-term president" (Barr, 2010).

A half century prior, though, the ideological differences between Democrats and Republicans were relatively minimal. This changed during the 1960s and 1970s as key social developments, including the Civil Rights Movement (Collins, 1997), Vietnam War protests (Young, 2015), and the Women's Rights Movement (Friedan, 1963), brought to the surface significant ideological rifts (Farber, 1994.).

By the 1990s, the "Republican Revolution" and the rise of figures such as Newt Gingrich shifted the GOP’s legislative approach, making obstruction a central strategy in Congress (Strahan & Palazzolo, 2004). This shift intensified with McConnell’s use of the filibuster (McConnell, 2019), leading to increased legislative gridlock that helped further polarize Congress (Rahman, 2018) as well as the American public. Donald Trump’s first presidency deepened this polarization (Dimock & Gramlich, 2021) but was also a reflection of an existing trend rather than its origin (“U.S. is polarizing faster”, 2021).

The Growth of News Bias in the United States

The decline of local newspapers and traditional news media has coincided with the growth of the internet, which has transformed the news industry (Barthel et al., 2020) and contributed to increased political polarization (Ellger et al., 2024). From 2006 to 2020, newspaper advertising revenue declined by over 80% and newsroom employment fell from 75,000 to 30,000 (Insoll, 2022). Local newspapers have been hit particularly hard, with approximately one-quarter of all U.S. newspapers closing in the last two decades, creating vast "news deserts" (Zayed, 2023).

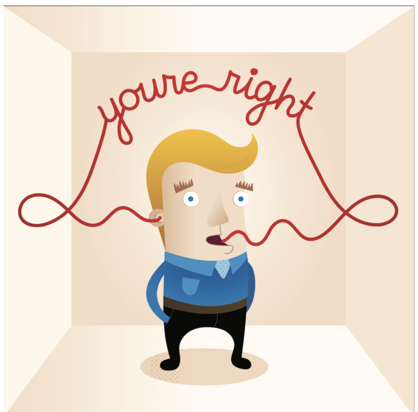
The rise of cable news networks and talk radio has also contributed to news bias, with Fox News, MSNBC, and CNN each providing politically distinct perspectives. Today, there are countless outlets, and now podcasts, that cater to a person’s specific world view, serving to reinforce their already established perspective. Studies have found that viewers of partisan news outlets tend to have stronger negative feelings toward the opposing party, a phenomenon known as "affective polarization" (Iyengar et al., 2019). This has been intensified by the shift toward entertainment-focused news, where neutral commentary—if not accurate reporting itself—is often deprioritized for engagement (Griffing, 2023).

The Role of Social Media in Reinforcing Bias and Misinformation

Social media has further fragmented the American news landscape, creating echo chambers (see Figure 1) where users are exposed primarily to information that aligns with their pre-existing beliefs (Cinelli et al., 2021). During the 2016 U.S. presidential election, platforms like Facebook actively tailored content to align with users' political views, deepening ideological divides (Kim et al., 2018). Algorithms prioritize content that maximizes engagement, which can inadvertently amplify misinformation; in fact, misinformation on Facebook received six times the engagement of factual news during the 2020 election (Edelson et al., 2021).

Figure 1

Graphic Depiction of an Echo Chamber (European Center for Populism Studies)



Note. This image appears on the page "Echo Chamber" in the Dictionary of Populism *by the European Center for Populism Studies.*

The widespread use of smartphones has facilitated this issue, with about 86% of Americans receiving news digitally (Pew Research Center, 2024a) and approximately half getting their news at least part of the time from social media (Pew Research Center, 2024b). It is, thus, problematic that Meta recently announced it has eliminated its factchecking program (Chan et al., 2025) and will instead rely on "community notes", similar to what X now provides.

Another component to this problem is the role Russia has recently played in efforts to divide Americans and erode their trust in U.S. institutions. For instance, during the 2016 federal election, Russian operatives clandestinely created social media pages and profiles meant to pit Americans of multiple political persuasions against each other. In one example, Russia created a Facebook group with 250,000 followers that opposed the Islamization of Texas while creating another Facebook group—"United Muslims of America"—with 328,000 followers. The effort resulted in what essentially became a protest and counterprotest on the same day, time, and location that turned confrontational. The cost of the ads promoting the protests were a mere $200 (Lucas, 2017).

Consequences of Political Polarization and News Digression

The increasing polarization has had severe consequences for American democracy. Studies indicate that the lack of reliable local news sources and the proliferation of social media misinformation contribute to a lower quality of governance, higher levels of political corruption, and greater partisanship among elected officials (Hook & Verdeja, 2022). The Economist Intelligence Unit (EIU) downgraded the U.S. from a "full democracy" to a "flawed democracy", citing significant erosion of democratic norms and processes (2016). Similarly, Freedom House's Democracy Score for the U.S. has declined by six points since 2017, from 89 (Freedom House, 2017) to 83 (Freedom House, 2024), partly due to increased political violence, misinformation, and election-related conspiracy theories (Freedom House, 2024).

A notable example of the impact of polarization was seen on January 6, 2021, when a mob attacked the United States Capitol on the false premise—fueled by partisans in the news and social media—that Trump had the presidential election stolen from him. Shortly after, 30 percent of Republicans and 11 percent of Democrats believed that "true American patriots might have to resort to violence in order to save our country" (Public Religion Research Institute, 2021).

Another notable example can be seen in public health, in which misinformation about COVID-19 contributed to a significant number of preventable deaths (Martinez & Aubrey, 2022). By 2022, analysis suggested that nearly 319,000 deaths could have been prevented had every adult been vaccinated (Simmons-Duffin & Nakajima, 2022). Unlikely as this may have been, it suggests that without the scourge of mass misinformation, a better public information campaign and adherence to health guidelines would have saved, perhaps, hundreds of thousands of lives.

The Cycle of Misperceptions

Yet, despite the evidence above, the polarization effect is also magnified by public misperceptions regarding the *extent* of ideological differences. Research by the Carnegie Foundation suggests that Americans may not be as polarized as they perceive themselves to be, with overlap in views on issues like gun control and reproductive rights (Kleinfeld, 2023). The research surmises that the greatest misperceptions are held by the most politically active who hold the strongest feelings against their opposing party. It's worth noting that such Americans are also more likely to consume partisan news (Stroud & Curry, 2015).

For years, political scientists pondered if the growth in public polarization was caused by elected officials becoming more polarized, or if *political* polarization was caused by the *public* becoming more polarized. Whether the former or the latter, elected officials are, in fact, highly polarized (Kleinfeld, 2023). This is not likely to change anytime soon in Congress. There, the proliferation of gerrymandering by both parties and non-competitive congressional districts (Cillizza, 2021) only serve to incentivize partisanship in order for candidates to win primaries and stay in office. As previously discussed, such partisanship in Congress causes public polarization, which is exacerbated by the state of news and social media in the United States. And the cycle continues.

Concluding Thoughts

A shift in media standards and the rise of biased news sources have not only intensified polarization but fostered the perception of a real—yet exaggerated—nation divided. Further, the decline of local news, growth of partisan media, and prevalence of misinformation on social platforms have each played a role in deepening this divide, affecting the quality of democratic governance in the United States.

Moving forward, understanding and mitigating the effects of media digression on political polarization will be critical to fostering a healthier democratic society.

Among the tools most championed to lay this foundation is media literacy education at the grade school level—*before* young people become politically entrenched and, hopefully, begin to vote. While the data surrounding the efficacy of such education is limited, what is available has shown the ability to counteract the effects of misinformation (Huguet, 2019). This is important, because research indicates that young people lack even the most basic skills to circumnavigate the perils of the digital age (Breakstone et al., 2019).

At the same time, just seven of 50 states have taken "significant steps toward comprehensive media literacy education" through legislation, reports Media Literacy Now, a self-described "politically neutral advocacy nonprofit." Another 12 states have "advanced media literacy" through legislation; while seven separate states have "legislation pending" (McNeill, 2024).

But like many educational efforts in the United States, funding has proven to be a challenge (DiGiacomo et al., 2023). And ironically—or perhaps, fittingly—politics could also prove an inhibitor. Education in the United States is largely determined by the individual states, most of which lean progressive or conservative. Efforts to improve media literacy also provide the opportunity for partisan lawmakers to cast certain outlets or perspectives as factual at the expense of those counter to their own ideologies (Sailer, 2021). One could argue, then, that there is no silver bullet to cure polarization in the United States—other than the will to do so.

At the very least, there ought to be bipartisan support for media literacy education since it need not exclusively focus on news or politics. According to the U.S. Surgeon General, "The mental health crisis among young people is an emergency — and social media has emerged as an important contributor" (Murthy, 2024).

For this reason, the U.S. Surgeon General has issued numerous suggestions regarding social media policy and best practices to policymakers, technology companies, parents and caregivers, and children and adolescents. But among them is, critically, developing efforts toward "learning and utilizing digital media literacy skills to help tell the difference between fact and opinion" (U.S. Surgeon General, 2023).

References

Barr, A. (2010). The GOP's no-compromise pledge. *POLITICO*. United States. [Web Archive]. https://www.politico.com/story/2010/10/the-gops-no-compromise-pledge-044311

Barthel, M., Mitchell, A., Asare-Marfo, D., Kennedy, C., & Worden, K. (2020). Measuring news consumption in a digital era. *Washington, DC: Pew Research Center*.

Breakstone, J., Smith, M., Wineburg, S., Rapaport, A., Carle, J., Garland, M., & Saavedra, A. (2019). Students' civic online reasoning: A national portrait. Stanford History Education Group & Gibson Consulting. https://purl.stanford.edu/gf151tb4868

Chan, K., Ortutay, B., & Riccardi, N. (2025). Meta eliminates fact-checking in latest bow to Trump. *AP news*. https://apnews.com/article/meta-facts-trump-musk-community-notes-413b8495939a058ff2d25fd23f2e0f43

Cillizza, C. (2021, December 10). How both parties are killing competition in the race for the House. *CNN*. https://edition.cnn.com/2021/12/10/politics/redistricting-map-house-2022-election/index.html

Cinelli, M., De Francisci Morales, G., Galeazzi, A., Quattrociocchi, W., & Starnini, M. (2021). The echo chamber effect on social media. *Proceedings of the National Academy of Sciences*, *118*(9), e2023301118.

Collins, K. (1997). The Civil Rights Movement: A Photographic History, 1954-68. *Library Journal*, *122*(1), 92-94.

DiGiacomo, D. K., Hodgin, E., Kahne, J., Alkam, S., & Taylor, C. (2023). Assessing the state of media literacy policy in U.S. K-12 schools. *Journal of Children and Media*, *17*(3), 336–352. https://doi.org/10.1080/17482798.2023.2201890

Dimock, M., and Gramlich, J. (2021, January 29). How America changed during Trump's presidency. *Pew Research Center*. https://www.pewresearch.org/politics/2021/01/29/how-america-changed-during-donald-trumps-presidency/

"Echo Chamber". *Dictionary of Populism*. European Center for Populism Studies. https://www.populismstudies.org/Vocabulary/echo-chamber/

Economist Intelligence Unit. (2016). *Democracy index 2016: Revenge of the deplorables.* https://www.eiu.com/public/topical_report.aspx?campaignid=DemocracyIndex2016

Edelson, Laura, Minh-Kha Nguyen, Ian Goldstein, Oana Goga, Damon McCoy, and Tobias Lauinger. (2021). "Understanding engagement with US (mis) information news sources on Facebook." In *Proceedings of the 21st ACM internet measurement conference*, pp. 444-463.

Ellger, F., Hilbig, H., Riaz, S., & Tillmann, P. (2024, October 23). Local newspaper decline and political polarization – Evidence from a multi-party setting. *British Journal of Political Science*. Cambridge University Press. doi:10.1017/S0007123424000243

Farber, D. (1994). *The age of great dreams: America in the 1960s*. Macmillan.

Freedom House (2017). *Freedom in the world 2017: United States*. https://freedomhouse.org/country/united-states/freedom-world/2017

Freedom House (2024). *Freedom in the world 2024: United States*. https://freedomhouse.org/country/united-states

Friedan, B. (1963). The Feminine Mystique. WW Norton.

Griffing, A. (2023, August 28). *Cable news shows and networks ranked for bias and accuracy*. MEDIAITE. https://www.mediaite.com/news/cable-news-shows-and-networks-ranked-for-bias-and-accuracy/

Hook, K. and Verdeja, E. (2022). Social media misinformation and the prevention of political instability and mass atrocities. *Human security and governance*. Stimson. https://www.stimson.org/2022/social-media-misinformation-and-the-prevention-of-political-instability-and-mass-atrocities

Huguet, A., Kavanagh, J., Baker, G., & Blumenthal, M. S. (2019 July 11). *Exploring media literacy education as a tool for mitigating truth decay*. RAND Corporation. https://www.rand.org/pubs/research_reports/RR3050.html

Insoll, L. (2022 Jan 11). Can automated advertising save America's newspapers? *In Context*. Digital Content Next.

Iyengar, S., Lelkes, Y., Levendusky, M., Malhotra, N., & Westwood, S. J. (2019). The origins and consequences of affective polarization in the United States. *Annual review of political science*, *22*(1), 129-146.

Kim, Y. M., Hsu, J., Neiman, D., Kou, C., Bankston, L., Kim, S. Y., ... & Raskutti, G. (2018). The stealth media? Groups and targets behind divisive issue campaigns on Facebook. *Political Communication*, *35*(4), 515-541.

Kleinfeld, R. (2023). *Polarization, democracy, and political violence in the United States: What the research says*. CEIP: Carnegie Endowment for International Peace. https://coilink.org/20.500.12592/f3v5zr

Lucas, R. (2017, November 1). How Russia used Facebook to organize 2 sets of protesters. *All Things Considered*. National Public Radio. https://www.npr.org/2017/11/01/561427876/how-russia-used-facebook-to-organize-two-sets-of-protesters

Martinez, A., & Aubrey, A. (2022, May 16). How vaccine misinformation made the COVID-19 death toll worse. *Morning Edition*. National Public Radio. https://www.npr.org/2022/05/16/1099070400/how-vaccine-misinformation-made-the-covid-19-death-toll-worse

McConnell, M. (2019). The Filibuster Plays a Crucial Role. *The New York Times*, A23-L.

McNeill, E. (2024, February). *U.S. media literacy policy report*. Media Literacy Now. https://medialiteracynow.org/wp-content/uploads/2024/02/MediaLiteracyNowPolicyReport2023_publishedFeb2024b.pdf

Murthy, V. H. (2024, June 17). Surgeon general: Why I'm calling for a warning label on social media platforms. *New York Times*.

Pew Research Center (2024a). *News platform fact sheet*. https://www.pewresearch.org/journalism/fact-sheet/news-platform-fact-sheet/#:~:text=patterns%20and%20trends.-

,News%20consumption%20across%20platforms,%25)%20or%20print%20(4%25)

Pew Research Center (2024b). *Social media and news fact sheet*. https fact://www.pewresearch.org/journalism/fact-sheet/social-media-and-news--sheet/

Public Religion Research Institute, (2021, November 1). *Competing Visions of America: An Evolving Identity or a Culture Under Attack?* https://www.prri.org/research/competing-visions-of-america-an-evolving-identity-or-a-culture-under-attack/

Rahman, K. S. (2018). Reconstructing the Administrative State in an Era of Economic and Democratic Crisis. *Harvard Law Review, 131*(6). https://harvardlawreview.org/print/vol-131/reconstructing-the-administrative-state-in-an-era-of-economic-and-democratic-crisis/

Sailer, J. (2021, December 9).CRT in practice, the parents' Bill of Rights, and social media literacy. *Resolute*. Civics Alliance from National Association of Scholars. https://www.nas.org/blogs/article/crt-in-practice-the-parents-bill-of-rights-and-social-media-literacy

Simmons-Duffin, S., & Nakajima, K. (2022, May 13). This is how many lives could have been saved with COVID vaccinations in each state. *All Things Considered*. National Public Radio. https://www.npr.org/sections/health-shots/2022/05/13/1098071284/this-is-how-many-lives-could-have-been-saved-with-covid-vaccinations-in-each-sta

Strahan, R., & Palazzolo, D. J. (2004). The Gingrich Effect. The Gingrich Effect. *Political Science Quarterly 119*(1), 89-114.

Stroud, N. J. & Curry, A. (2015, November 5). 15 - The polarizing effects of partisan and mainstream news, In J. A. Thurber and A. Yoshinaka, Eds., PART IV – Polarization in the Media. Cambridge University Press. https://www.cambridge.org/core/books/abs/american-gridlock/polarizing-effects-of-partisan-and-mainstream-news/4B0FAE9C44BE5B7841211C5BD5A1B651

U.S. is polarizing faster than other democracies, study finds. (2021, January 21). Brown University. https://www.brown.edu/news/2020-01-21/polarization

U.S. Surgeon General. *Social media and youth mental health 2023: The U.S. Surgeon General's Advisory*. Department of Health and Human Services. https://www.hhs.gov/sites/default/files/sg-youth-mental-health-social-media-advisory.pdf

Young, M. B. (2015). The Vietnam War in American Memory. In *The Vietnam War: Vietnamese and American Perspectives* (pp. 248-257). Routledge.

Zayed, M. (2023). *The Rise of the News Desert: A Study on the Effect of Local Newspaper Closures on the American Public's Trust of Government* (Doctoral dissertation, Georgetown University).

Author Details

Yianni Varonis
Political and Communications Consultant
U.S.A.
yiannivaronis@gmail.com

A PROPOSAL FOR AN IMMERSIVE VIRTUAL REALITY COMPETENCIES FRAMEWORK FOR HISTORY TEACHERS: TOWARDS A SPECIALIZATION OF TPACK

Aránzazu García-Martínez, *University of Burgos*, SPAIN
Víctor Gómez-Muñiz, *Universidad de Vitoria Gasteiz EUNEIZ,* SPAIN
Elisa Serrano-Ausejo, *Umeå University*, SWEDEN
Peter Mozelius, *University of Gävle & Mid Sweden University*, SWEDEN

Abstract

History education faces challenges engaging students due to its complexity, hindering understanding of key concepts like causality or multiperspectivity. Immersive virtual reality (iVR) is being broadly implemented in heritage institutions, and some history teachers are beginning to explore its potential to support learning. However, insufficient technological-pedagogical knowledge complicates its implementation while the competencies needed for K-12 history teachers remain unexplored. Knowledge required to effectively implement iVR in history education is presented, aiming to discuss a model covering the various areas that should be developed for successful history education through iVR.

Introduction

Immersive technologies such as virtual reality (VR) and augmented reality (AR) are giving new opportunities in many fields, including education. VR has been found in educational contexts since the 1960s (Page, 2000), even if the term VR was coined as late as 1989 (Rheingold, 1991). In the 21st century there has been a fast development of new VR technologies where the so-called second wave of VR has brought on a wide variety of new displays and input devices that has increased the sense of immersion (Anthes et al., 2016). In AR applications, the real world can interact with the virtual, while VR applications are completely disconnected from the real world. In the fast technological development where VR has become more and more alike to the real world, two different types of VR can be identified: 1) Non-immersive VR and 2) Immersive VR (iVR).

While the first type consists of a computer-based environment that simulates contexts in the real or imagined worlds, iVR more strongly gives the user a perception of being physically present in a non-physical world. Non-immersive VR can be installed on, and run from, standard computers, while iVR applications need special devices such as head mounted displays (Freina & Ott, 2015). The combination of immersion and interaction functionalities in iVR applications make these environments useful in education. Educational iVR applications enable learners to experience worlds and topics that could be impossible or dangerous to visit in real-world settings (Kavanagh et al., 2017; Serin, 2020). In the context of history education, impossible worlds in the past could be exemplified as a city tour around lost heritage and urbanism (Checa et. al. 2019, Villena et al., 2022).

Research studies have explored and discussed pedagogical possibilities (Häfner et al., 2018) and motivational aspects (Stepan et al., 2017). However, there are fewer studies discussing how iVR should best be used and applied in the more specific field of history education (Serrano-Ausejo & Mozelius, 2024). iVR for education requires specific competences that should relate to the specifics of the technology itself. These competences are framed within the European competencies' digital framework and the Technological Pedagogical Content Knowledge framework (see "Theoretical Framework" section below), that was proposed by Punya Mishra and Matthew Koehler (2006). Grounding on these two theoretical pillars, the authors' aim is to present and discuss a specific framework that can be used for iVR-based history education.

Theoretical Framework

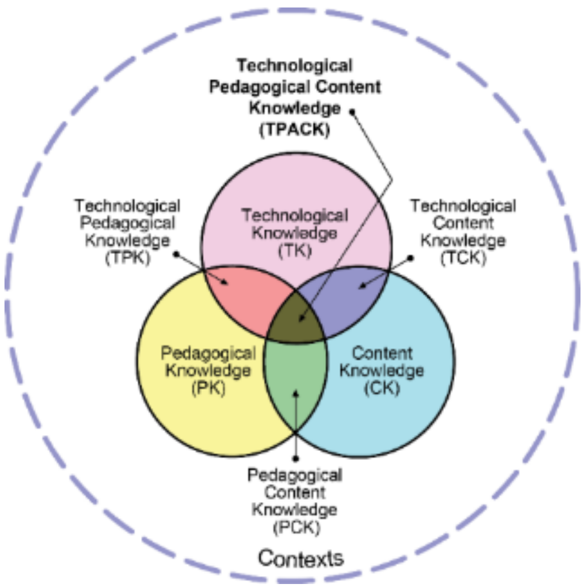
This study is grounded in the Technological pedagogical content knowledge framework (TPACK) and the European Digital Competences Framework.

Technological Pedagogical Content Knowledge

The TPACK framework (Mishra & Koehler, 2006), delineates three domains of knowledge essential for integrating technology into teaching: pedagogical knowledge (PK), content knowledge (CK), and technological knowledge (TK). These domains encompass teachers' expertise in didactics and pedagogy (PK), subject matter (CK), and technological proficiency (TK). The interaction of these domains forms new areas of knowledge (Figure 1). Technological Content Knowledge (TCK) is the integration of technology and content knowledge, exemplified by the use of iVR applications to enhance history education. Pedagogical Content Knowledge (PCK) focuses on selecting pedagogical strategies suitable for specific content areas. Technological Pedagogical Knowledge (TPK) involves applying appropriate pedagogical approaches to support the chosen technology. In this study, it includes how history teachers might adapt their pedagogical strategies when using iVR compared to traditional text-based activities (Mishra & Koehler, 2006; Koehler & Mishra, 2008).

Figure 1

The TPACK Model



Note: Image from tpack.org (2012); site is currently inactive. Alternative reference available at Mishra (2018).

TPACK gives an overall understanding of the competencies that must be developed by the teacher who wants to implement technology, but it is insufficient to understand the different levels of technology involvement in teaching, from a basic to a proficient level. To complete TPACK, the following framework was employed.

The European Digital Competences Framework

The European Commission has launched an initiative on digital competence with the intention of improving the digital skills of citizens in different areas. This initiative has been embodied in the European Digital Competences Framework (DIGCOMP) for European citizens. In 2017, in different countries such as Austria, Ireland, Spain, Norway, and Germany among others, the initiative to apply it to education was launched, and for this reason the European Commission generated a new initiative to guide teachers about the different digital competencies, the Digital Competence Framework for Teaching (DIGCOMPEDU). The Digital Competence Framework for Teachers (Redecker, 2017), categorised six areas of digital knowledge (Figure 2): professional engagement, digital content, teaching-learning process, assessment and feedback, learner empowerment, and development of learner digital competence.

Figure 2

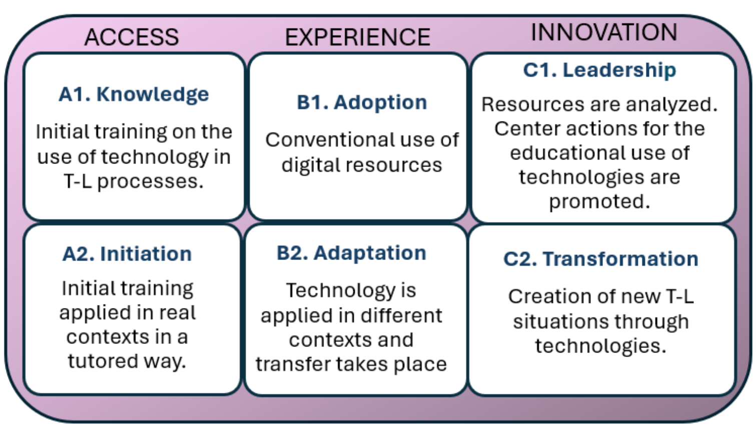
European Framework for the Digital Competence of Educators

Note: Image from Redecker (2017).

Each of these areas corresponds to the following levels of competence: A1, A2, B1, B2, C1, and C2, where level A gives basic access to technology, level B gives experience and level C refers to the capacity for teaching innovation through technology (Figure 3).

Figure 3.

Teachers' Digital Competence Framework



Note: Image from Spanish Ministry of Education, 2022. Translation by the authors.

Methodology

This is a Position paper that relies on the expertise of three experts engaged in iterative discussions to establish a consensus in order to define the essential competencies framework required for history education through iVR. They fulfilled the required inclusion criteria: 1) possessing a higher education degree in history, ensuring a deep understanding of the discipline; 2) expertise in teacher education, ensuring consideration of the knowledge and competencies students need to develop in history and the requisite didactics; 3) substantial knowledge and experience in iVR for educational purposes, crucial for discussing the necessary competencies for effective history teaching via iVR; and 4) a perception of history education as a contemporary field where students are encouraged to be critical and active learners, moving away from repetition and memorization.

It's worth noting that all three experts are also authors of this study, each holding master's degrees in social sciences teaching. To extend the informants' knowledge of technology and the instructional possibilities of iVR, this Position paper draws on extensive discussions with researchers from the Centre for Innovation and Technology in Video Games and Audiovisual Communication (ÍTACA) at Burgos University and a pilot project funded by Erasmus + where four teachers were instructed according to the model. However, this Erasmus project is still a work in progress and can not offer clear results yet.

Results

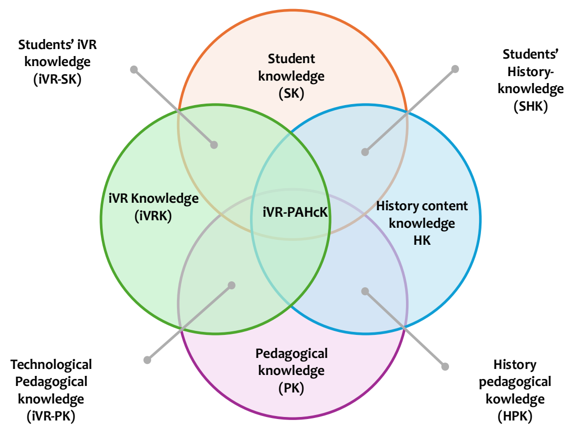
The results of this study are drawn in two different models that are described below: 1) iVR Pedagogical History Knowledge framework (iVR-PAHCK) and 2) the iVR-ladder for history teachers' education in iVR.

iVR Pedagogical History Content Knowledge Model

The first model (Figure 4), adapted from TPACK for history education with iVR, includes four overlapping domains. In addition to the three domains of the TPACK model, a fourth domain focuses on teachers' understanding of students' technology and content knowledge. This knowledge is crucial in history education as it can influence learning outcomes (Noel Mera, 2023), communication of history, technology use, and even content adaptation based on students' backgrounds (Almerich et al., 2019, p. 61).

Figure 4

iVR-PAHCK Model

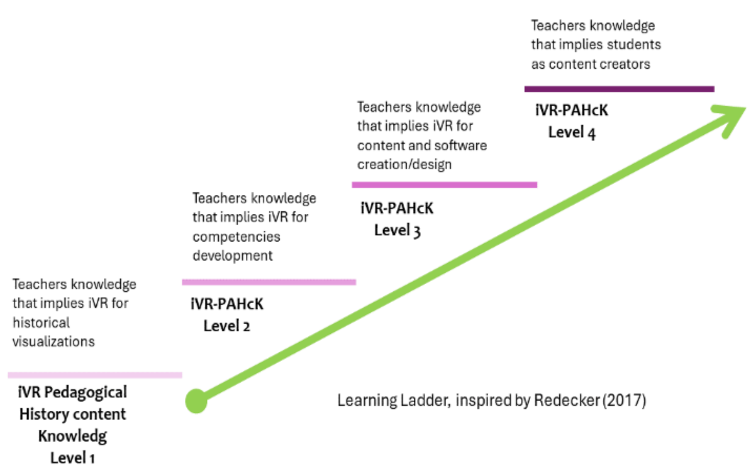


Note: Diagram is original work of the authors.

Illustrated in Figure 4, the iVR-PAHCK model creates four intersecting domains: 1) Students' iVR knowledge (iVR-SK); 2) students' history knowledge (SHK); 3) history pedagogical knowledge (HPK); 4) and iVR pedagogical knowledge (iVR-PK). This model proved effective to understand what knowledge is necessary for history teachers to implement iVR successfully, but it is insufficient to know the different levels of digital competence for history teaching and its implications for the learning outcomes. In order to describe the different competency levels of iVR for history education, a second model was created (Figure 5). The interaction of both models is essential, as iVR-PAHCK should be integrated into each step of the process to ensure successful implementation.

Figure 5

The iVR learning ladder for history teachers' education



Note: Diagram is original work of the authors.

The iVR-ladder for History Teachers' Education

The ladder metaphor represents a constructive learning process, building new knowledge upon the previous, ensuring a solid foundation, fostering certainty and facilitating success. Implementing new methods without necessary competencies can cause stress among stakeholders. While some space for trial and error is beneficial, lack of control and understanding may lead to resistance to teaching innovation. See Figure 5 for an overview of the suggested steps.

iVR Pedagogical History Content Knowledge, Level 1

The initial step involves integrating iVR to immerse students in historical experiences, enabling embodied interactions with historical objects and emotional engagement, thereby enhancing contextualization and understanding. Teachers must have a positive and curious attitude toward technology, and referring to Redecker's (2017) framework, teachers should acquaint themselves with the technology's functionalities and allocate resources and time to find suitable applications aligned with learning objectives. As teachers gain experience, their ability to troubleshoot technical issues is expected to improve, paralleling the growth of students' problem-solving skills in an iVR environment. Furthermore, teachers' capacity to design iVR-integrated lessons will expand with experience, progressing from standalone visualizations to interconnected activities that promote reflection and inquiry.

Crucial professional skills include research and analysis of suitable digital content and applications for history teaching and learning (Szlachta Junior, 2023, p. 42), getting familiar with existing platforms and databases. Besides, iVR content must be implemented critically and functionally, involving the design of units that start from learning goals and learning difficulties, and including ethical considerations that should consider the previous experiences of students in case emotions can be severely touched. Teachers must consider the new teaching-learning dynamics to maintain a positive educational environment, as iVR can dramatically alter the classroom setting. All in all, being aware of the changes the iVR will bring to the classroom to assure positive educational environments, being familiar with applications that are effective and appropriate for history education, plus designing proper units that work on goals and desired learning outcomes, would be the main competencies that frame this first step. The activities that involve iVR would involve visualizations, and interaction when available, while the whole unit might consider other actions such us reflection, conversations, or others.

iVR Pedagogical History Content Knowledge, Level 2

The implementation of iVR needs the design of virtual learning ecosystems adapted to various formative stages and different areas of K-12 education, creating customized pedagogical solutions (Rubio, 2023). Besides, the challenges faced by the educational system require students to be trained in evaluating content drawbacks to ensure the experience transcends mere entertainment (Miguélez-Juan et al., 2019, p. 163). This adds extra complexity for teachers and demands greater digital competence, as students need to learn about technology's limitations and drawbacks. This level focuses on using technology to support competency development, which is heavily dependent on the national or local curriculum.

Special emphasis is placed on critical thinking and historical consciousness. These competencies are generally established in many parts of the world and require a practical understanding of the subject. While iVR might help develop competencies such as imagination, considering the emotional impact of iVR on users (Kazlauskaité, 2022), critical thinking might be compromised (Serrano-Ausejo, 2023; Serrano-Ausejo & Mozelius, 2024).

Teachers working at this level of development are expected to enhance these competencies by supporting the analysis of sources and authorship, fostering a historical imagination that extends beyond the given narrative, and connecting the present to the past and the past to the future. This approach goes beyond visualizing content and narratives, requiring more active engagement. Technologically, the teacher masters the available platforms and software, builds a supportive teachers' network to implement new pedagogical experiences that support competency development, learns how to solve technological failures, and achieves a deep understanding of the technology in use as well as students' reactions and their trust.

iVR Pedagogical History Content Knowledge, Level 3

At this level, teachers skilled in Virtual Reality Knowledge (iVRK) and pedagogy (iVR-PK) create and develop content, needing continuous knowledge updates to adapt methodologies and proficiently utilize resources. Evidenced by Cabero-Almenara et al. (2018, p. 75) the change to active methodologies cannot occur without an assimilation and transmission of knowledge by the teacher.

The creation of iVR pedagogical materials involves a series of teaching skills that include programming, computer validation, image processing or rendering, among others (Nikou et al., 2022, p. 205), besides a critical approach that directly connects content created with pedagogical goals. The difficulty of the task is high and corresponds to a level C1-C2 of The European proposal (see Figure 3). It includes aspects such as creation but goes further by pointing out aspects as reuse, sharing, and management of resources. Therefore, the management of the different licensing systems is another skill that the teacher must acquire, either for reuse, or for creation (García Nincehelser, 2018). As Nikou et al. (2023) suggest, the modification of resources for reuse and adaptation in different contexts should be considered in the creation process. A collaboration among teachers with the aim to transform classroom praxis by putting technological resources (Raposo-Rivas & Escola, 2016) is especially important for iVR material, due to the time and skills needed for development. Consequently, teacher collaboration will lead to distributed leadership and empowerment in the classroom facilitated by autonomy and new knowledge (Aleman-Saravia, 2023, p. 25). Overall, training on platforms or engines that enable the design, creation, transfer, and sharing of models would empower teachers to virtually shape their own vision of the virtual content they wish to use, keeping them away from other content that may not have been created for educational purposes.

iVR Pedagogical History Content Knowledge, Level 4

The fourth level emphasizes the importance of students' prior technology knowledge (iVR-SK). Despite being digital natives, students often lack the necessary skills for critical and advanced use of technology. Also, research by Helsper and Eynon (2010) demonstrates that teachers trained in digital competencies can surpass students in learning-related competencies, enabling them to create self-regulating activities (Reginald, 2023). In an immersive environment, teachers can help students create their own historical iVR content, acting as digital historians and applying their own vision of history and previous knowledge.

The shift towards content creation is significant as the visualization and embodiment features of iVR, which were once the most considered, now share the spotlight with content creation possibilities. This creative process manifests in diverse ways, with the Cospaces platform emerging as a favorite among teachers (Gomez Muñiz, 2021a, 2021b). It's a platform where students can program their own content, whereby also acquiring basic programming skills. They can create environments and incorporate animations, sounds, stories, and text. Other examples are 360 videos, 3D modelling, and photogrammetry, which vary in complexity and skill requirements. This technology allows students to apply prior knowledge and offer their own perspectives on history after reviewing sources, moving away from predetermined narratives. This aligns with level 6 of the Redecker framework, which focuses on fostering students' digital competence, autonomy, and empowerment (Redecker, 2017). It is expected that the teacher has mastered the level 3, so she can transfer the creation and creative skills to the students, but also comprehending the diversity in iVR-SK in the group is essential to support those with lower previous technological knowledge. Besides, those students with low SHK might need some motivation to implement historical content in their creations.

Discussion and Conclusion

A competent teacher in iVR-PAHCK is suggested to help students acquire historical competencies through iVR, facilitating a scaffolding process that considers students' individual backgrounds and aims for high digital competence. Teachers' learning is structured in four steps, each resulting in different learning outcomes. Each of the steps requires knowledge of the teacher organised in technological, content, and pedagogical knowledge under the influence of TPACK, but adds an extra domain involving knowledge regarding students' previous knowledge in the subject and in the technology.

The choice of a ladder as a metaphor for the model was due to the increase of complexity. This might suggest that history educators, at least those with low or basic knowledge in iVR, should start at level 1 and 2 (visualizations and competencies development) before they take a role as iVR designers or content creators. Also, they have to be aware of the difficulties that level 4 implies, where students might feel frustrated if they lack sufficient digital competence. However, considering the future that awaits today's students, it is convenient to help them to master digital technologies, while a modernization of the subject might also help in its survival.

Further work will test the model on a broader number of teachers, aiming for validation that has not yet been confirmed.

References

Aleman-Saravia, A. C. (2023). Gestión del contexto de aprendizaje docente para dinamizar el tpack-21 en comunidades de aprendizaje profesional. [Doctoral dissertation, Universidad San Ignacio de Loyola]. https://repositorio.usil.edu.pe/server/api/core/bitstreams/3f8848ae-37e9-4721-b37c-a49e7ae2f528/content

Almerich, G., Suárez-Rodríguez, J., Díaz-García, I., & Orellana, N. (2019). Estructura de las competencias del siglo XXI en alumnado del ámbito educativo. Factores personales influyentes. *Educación XX1, 23*(1), 45–74. https://doi.org/10.5944/educxx1.23853

Anthes, C., García-Hernández, R. J., Wiedemann, M., & Kranzlmüller, D. (2016). State of the art of virtual reality technology. In *2016 IEEE Aerospace Conference* (pp. 1-19). IEEE. https://doi.org/10.1109/AERO.2016.7500674

Cabero-Almenara, J., Horra Villacé, I. de la, & Sánchez Bolado, J. (2018). *La realidad aumentada como herramienta educativa: Aplicación a la educación infantil, primaria, secundaria y bachillerato*. Ediciones Paraninfo.

Checa, D., Alaguero, M., & Bustillo, A. (2019). Un entorno de realidad virtual inmersiva para descubrir el patrimonio perdido. In R. J. Payo Hernanz, E. M. Martínez de Simón, J. Matesanz del Barrio, & M J. Zaparaín Yáñez (Eds.), *Vestir la arquitectura: XXII Congreso Nacional de Historia del Arte, Vol. 2, 2019* (pp. 1597-1602). Burgos.

Freina, L., & Ott, M. (2015). A literature review on immersive virtual reality in education: State of the art and perspectives. In *The international scientific conference elearning and software for education (eLSE)*, pp. 133-141. https://proceedings.elseconference.eu/index.php?paper=b5bc8a20809b5689c689a7fec40255e6

García Nincehelser, M. E. (2018). *Recursos educativos abiertos: Oportunidades y barreras*. [Doctoral dissertation, Universidad de Burgos]. http://hdl.handle.net/10259/5057

Gómez Muñiz, V. (2021a). Diseño y creación de museos virtuales con realidad aumentada. *Comunicación y Pedagogía: nuevas tecnologías y recursos didácticos, 329*, 56-59. https://dialnet.unirioja.es/servlet/articulo?codigo=7980211

Gómez Muñiz, V. (2021b). *Dioramas virtuales. Estudiando la Historia del Arte a través de la realidad aumentada*. Instituto nacional de tecnologías educativas y de formación del profesorado. https://intef.es/recursos-educativos/experiencias-educativas-inspiradoras/detalle-experiencias/?id=23603

Häfner, P., Dücker, J., Schlatt, C., & Ovtcharova, J. (2018). *Decision support method for using virtual reality in education based on a cost-benefit-analysis*. 4th International Conference of the Virtual and Augmented Reality in Education, VARE 2018, 103–112.

Helsper, E. J., & Eynon, R. (2010). Digital natives: Where is the evidence? *British Educational Research Journal, 36*(3), 503–520. https://doi.org/10.1080/01411920902989227

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of virtual reality in education. *Themes in science and technology education, 10*(2), 85-119. https://www.learntechlib.org/p/182115/

Kazlauskaitė, R. (2022). Knowing is seeing: Distance and proximity in affective virtual reality history. *Rethinking History, 26*(1), 51-70. https://doi.org/10.1080/13642529.2022.2031803

Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Ed.), *The handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3-29). Lawrence Erlbaum Associates.

Miguélez-Juan, B., Núñez Gómez, P., & Mañas-Viniegra, L. (2019). La Realidad Virtual Inmersiva como herramienta educativa para la transformación social: Un estudio exploratorio sobre la percepción de los estudiantes en Educación Secundaria Postobligatoria. *Aula Abierta, 48*(2), 157. https://doi.org/10.17811/rifie.48.2.2019.157-166

Mishra, P. (2018, September 10). The TPACK diagram gets an upgrade. Punya Mishra. *https://punyamishra.com/2018/09/10/the-tpack-diagram-gets-an-upgrade/*

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Nikou, S. A., Perifanou, M., & Economides, A. A. (2022). Towards a teachers' augmented reality competencies (TARC) framework. In M. E. Auer & C. Global (Eds.), *New Realities, Mobile Systems and Applications* (pp. 203–212). https://doi.org/10.1007/978-3-030-96296-8_19

Nikou, S. A., Perifanou, M., & Economides, A. A. (2023). Development and validation of the teachers' augmented reality competences (TARC) scale. *Journal of Computers in Education*. https://doi.org/10.1007/s40692-023-00288-6

Noel Mera, M. (2023). Enseñar a enseñar historia: una apuesta posible ante los desafíos actuales a la formación docente inicial. In J. Domínguez Cardiel, M. Alvarado Sánchez, & H. Torres Salazar (Eds.), *La historia: investigación y su enseñanza en tiempos pandémicos* (pp. 253–270).

Page, R. L. (2000). Brief history of flight simulation. *SimTecT 2000 Proceedings*, 11-17. Available at https://ohiostate.pressbooks.pub/app/uploads/sites/45/2017/03/FlightSimulation.pdf

Raposo-Rivas, M., & Escola, J. (2016). Comunidades virtuales de y para el aprendizaje. *Journal for Educators, Teachers and Trainers, 7*(2), 6–10.

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. In Y. Punie (Ed.), *EUR 28775 EN.* Publications Office of the European Union, Luxembourg. https://data.europa.eu/doi/10.2760/159770

Reginald, G. (2023). Teaching and learning using virtual labs: Investigating the effects on students' self-regulation. *Cogent Education, 10*(1). https://doi.org/10.1080/2331186X.2023.2172308

Rheingold, H. (1991). *Virtual reality: exploring the brave new technologies*. Simon & Schuster Adult Publishing Group.

Rubio, A. D. J. (2023). A balanced design of digital tools in primary education. In A. Kurt (Ed.), *Perspectives on Digital Burnout in Second Language Acquisition* (pp. 195-221). IGI Global. https://doi.org/10.4018/978-1-6684-9246-8.ch009

Serin, H. (2020). Virtual reality in education from the perspective of teachers. *Amazonia Investiga, 9*(26), 291-303. https://doi.org/10.34069/AI/2020.26.02.33

Serrano-Ausejo, E. (2023). Exploring history educators' motives for using immersive virtual reality in history teaching – a technology acceptance model analysis. In Proceedings of ICERI 2023 (pp. 4546–4554). IATED. https://library.iated.org/publications/ICERI2023

Serrano-Ausejo, E., & Mozelius, P. (in press). Design of virtual reality environments to support learning in history education. In *10th Proceedings of Immersive Learning Research Network, ILRN*. Glasgow, Scotland, June 10–13, 2024.

Spanish Ministry of Education. (2022). Marco de referencia de la competencia digital docente (p. 196). https://intef.es/competencia-digital-educativa/competencia-digital-docente/

Stepan, K., Zeiger, J., Hanchuk, S., Del Signore, A., Shrivastava, R., Govindaraj, S., & Iloreta, A. (2017). Immersive virtual reality as a teaching tool for neuroanatomy. *International Forum of Allergy & Rhinology,* 7(10), 1006–1013. https://doi.org/10.1002/alr.21986

Szlachta Junior, A. M. (2023). La realidad aumentada en la enseñanza crítica de la historia. In J. Domínguez Cardiel, M. Alvarado Sánchez, & H. Torres Salazar (Eds.), *La historia: investigación y su enseñanza en tiempos pandémicos* (pp. 40–52).

Villena Taranilla, R., Cózar-Gutiérrez, R., González-Calero, J. A., & López Cirugeda, I. (2022). Strolling through a city of the Roman Empire: An analysis of the potential of virtual reality to teach history in Primary Education. *Interactive Learning Environments, 30*(4), 608-618. https://doi.org/10.1080/10494820.2019.1674886

Author Details

Aránzazu García-Martínez
University of Burgos
Spain
aranzazugm@ubu.es

Víctor Gómez-Muñiz
Universidad de Vitoria Gasteiz EUNEIZ
Spain
cuadernosdeherodoto@gmail.com

Elisa Serrano-Ausejo
Umeå University
Sweden
elisa.serrano@umu.se

Peter Mozelius
University of Gävle & Mid Sweden University
Sweden
Peter.Mozelius@miun.se

ROBOAQUARIA: ROBOTS IN AQUATIC ENVIRONMENTS TO PROMOTE STEAM AND ENVIRONMENTAL AWARENESS

Konstantinos Karampelas, Anastasia Pyrini, and George Sarrigeorgiou
University of the Aegean
GREECE

Laura Screpanti, Benedetta Castagna, and David Scaradozzi
Università Politecnica delle Marche
ITALY

Ana Sović Kržić
University of Zagreb
CROATIA

Abstract

The paper explores the potential of robotics in environmental education, focusing on the ROBOAQUARIA project. It highlights the importance of integrating robotics into education - particularly within the field of Science, Technology, Engineering, Arts and Mathematics (STEAM), emphasizing creativity, critical thinking, and problem-solving skills. Research indicates positive outcomes across various disciplines within STEAM, including environmental education. Several projects demonstrate the effective use of robotics in teaching about environment. The ROBOAQUARIA project aims to integrate educational robotics into marine environmental education, offering a holistic approach involving equipment provision, teacher training, and curriculum development. Findings suggest potential benefits for schools.

Introduction

This paper examines the potential of robotics to assist in environmental education. The topic is explored through an innovative project called *ROBOAQUARIA: Robots in Aquatic Environments to Promote STEM and Environmental Awareness* which will run from 2022 until 2025. It includes a consortium of six organizations from five countries: Italy, Cyprus, Croatia, Ireland, and Greece. The program is funded by the European Union and belongs to the ErasmusPlus category.

Robotics in education, particularly within the field of Science, Technology, Engineering, Arts and Mathematics (STEAM), garners significant attention from educators, researchers, and policymakers. It seamlessly integrates into the interdisciplinary curriculum, emphasizing creativity, critical thinking, and problem-solving skills essential for future citizens. Educators must adopt innovative approaches to incorporate robotics effectively rather than relying solely on traditional curricula. Robotics activities require a wide range of real-world skills that require careful activity design by teachers. Research indicates that robotics education contributes to cognitive, affective, and psychomotor goals across various disciplines within STEAM, enhancing learning outcomes and promoting positive attitudes toward technology (Conde et al., 2021; Darmawansah et al., 2023; Kalaitzidou & Pachidis, 2023). Such a discipline can be environmental education (Christidi & Christopoulou, 2022; Kanaki & Kalogiannakis, 2023). It is important to ensure that any attempt to integrate robotics and environmental study into curricula should have long-term impacts on schools by improving students' performance and helping the schools run more efficiently (Fullan, 2007).

The project focuses on that topic. After a literature review about robotics in environmental education, it presents the project ROBOAQUARIA, which serves as the context of the study. Its importance, innovation, and contribution are explained. Then, in the methodology section, the data collection and analysis are presented, which leads to the conclusion and basic findings.

Literature Review

Robotics can be combined with environmental studies (Christidi & Christopoulou, 2022; Kanaki & Kalogiannakis, 2023). Before specifying the characteristics of this study, it is crucial to identify findings from previous research studies on this topic.

Robotics in Environmental Education

Talib et al. (2020) conducted a comprehensive investigation into the potential integration of robotics within educational frameworks to disseminate knowledge pertaining to sustainability and environmental concerns. By administering a questionnaire to participants drawn from two distinct university cohorts, the researchers sought to gauge perceptions regarding the utility of robotics in environmental education. The findings illuminated a consensus among respondents regarding the efficacy of robotics in fostering engagement with environmental topics, concepts, and phenomena. Furthermore, it was established that robotics can serve as a catalyst for the development of crucial STEAM competencies, which are instrumental in cultivating environmentally conscious attitudes.

Texeira et al. (2018) conducted a study that aimed at leveraging robotics as an educational tool to address the pressing environmental challenge of electronic waste management in Brazil. Recognizing the gravity of the issue and the imperative for proactive intervention, the researchers orchestrated a series of pedagogical interventions targeting high school students. These interventions encompassed the exploration of reusable product concepts and the environmental ramifications thereof. A pivotal aspect of the study involved the creation of a booklet elucidating the intricacies of electronic waste utilization, which was subsequently disseminated to a wider audience. Additionally, students engaged in the construction of a robotic kit which comprised reusable components, thereby acquiring practical knowledge in robotics and gaining insights into environmental stewardship through a hands-on experience.

Ziouzios et al. (2021) embarked on a project centered on cultivating environmental empathy among primary school students in Greece through the innovative integration of robotics. Central to their methodology was the design and deployment of a specialized robot equipped with audio-visual capabilities to convey narratives and information pertinent to climate change, pollution, and sustainability. Following exposure to the robot's educational narratives, students participated in problem-based learning activities aimed at fostering creative ideation and solution-oriented thinking regarding future environmental challenges. Notably, pre and post-intervention assessments facilitated the quantification of changes in students' levels of environmental empathy, with overwhelmingly positive outcomes indicating the efficacy of the robotics-enhanced educational approach.

Ruiz Vicente et al. (2020) embarked on an ambitious endeavor to instill a nuanced understanding of climate change among elementary school students in Spain through the implementation of a project intitled *Sustainable City*. This multifaceted initiative, spanning 14 instructional sessions, leveraged project-based learning methodologies to immerse students in various aspects of climate change mitigation and adaptation. Students were tasked with utilizing robotics kits to design, program, and deploy robots capable of addressing challenges related to sustainable mobility, biodiversity conservation, renewable energy utilization, and waste management. The data, which was collected via questionnaires, underscored the significant knowledge acquisition and motivation engendered by the robotics-centric educational interventions.

Collectively, these studies highlight the transformative potential of integrating robotics into environmental education paradigms. By providing learners with hands-on experiences and interactive learning opportunities, robotics-based pedagogies not only enhance understanding of environmental concepts but also foster the development of critical thinking skills and problem-solving abilities essential for addressing contemporary environmental challenges. Moreover, the interdisciplinary nature of robotics education, encompassing elements of Science, Technology, Engineering, Arts, and Mathematics, aligns seamlessly with the holistic objectives of environmental education. Through active engagement with robotics, students are empowered to become proactive agents of environmental change, equipped with the knowledge, skills, and attitudes necessary to navigate the complex interplay between technology and environmental sustainability (Ruiz Vicente et al., 2020; Texeira et al., 2018; Talib et al., 2020; Ziouzios et al., 2021).

ROBOAQUARIA: The Study Context

It is therefore justified that robotics and STEAM can be integrated into environmental education (Ruiz Vicente et al., 2020; Texeira et al., 2018; Talib et al., 2020; Ziouzios et al., 2021). However, this necessitates adequate preparation. Schools and educational institutions must be appropriately organized for this integration. This entails ensuring that teachers, curricula, and educational infrastructure are conducive to activities involving robotics, including those related to environmental themes. Teachers should possess familiarity with STEAM and relevant pedagogies, such as project-based learning, inquiry teaching, and problem-solving. This enables them to implement STEAM-oriented innovations effectively and achieve desired cognitive, affective, and psychomotor objectives (Conde et al., 2021; Darmawansah et al., 2023).

This study aligns with the aforementioned findings as it seeks to integrate robotics into the realm of marine studies. Specifically, it is situated within the ongoing ROBOAQUARIA project. The primary objective of this project is to utilize educational robotics as an innovative tool to merge STEAM and marine environmental education. To accomplish this, the project engages various stakeholders, including teachers, learners, and education managers, to develop the requisite capacities and competencies for interdisciplinary teaching concerning digital transformation toward sustainable development. The project comprises five distinct components or work packages. The first involves fund management and oversight. The second entails the development of a methodological framework for pilot studies, complete with guidelines for teachers and schools. The third component focuses on the preparation of toolkits and lesson topics, consisting of aquatic robotic fish and accompanying educational materials, such as syllabi and activities. The fourth component encompasses the development of an electronic learning kit and lesson plans. Finally, the fifth component involves communication, dissemination, exploitation, and policy recommendations in collaboration with school partners and associated entities.

The ROBOAQUARIA project’s innovation and significance are underscored by several factors. Firstly, it explores the potential of STEAM and robotics in understanding marine ecosystems. Secondly, it operates across multiple European countries, each with its own national education context, and involves diverse organizations specializing in education and information and communication technologies (ICT). Thirdly, it adopts a holistic teaching approach that integrates technological equipment, including kits, software, and hardware, with educational tools, such as lesson plans, syllabi, and activities. Fourthly, the project aims not only to generate research output and findings but also to deliver instructional materials and packages for future use by teachers. Moreover, the project takes into account existing research findings, which inform and guide its activities. Teaching interventions within the project will emphasize active learner participation through project-based learning lesson plans and activities. These activities will include scientific discourse on marine challenges and programming of marine robotic kits, fostering teamwork, problem-solving, and evaluation. The learning outcomes will encompass both environmental subjects and robotics, with a focus on imparting knowledge, skills, and attitudes regarding the use of robotics in marine environmental studies. By adhering to these principles, the program is expected to be both innovative and effective (Fullan, 2007; Ruiz Vicente et al., 2020; Texeira et al., 2018; Talib et al., 2020; Ziouzios et al., 2021).

Methodology

This study examines the potential of schools to use robotics activities for teaching about marine environments. This will be explored by precisely defining the potential of the ROBOAQUARIA project to be implemented in schools and educational organizations effectively. In other words, it examines the potential of schools to successfully accommodate the innovation of this project. It is important to clarify research questions, data collection methods, and analysis steps (Cohen et al, 2017).

The Research Questions

The research questions focused on identifying whether any relevant project or intervention meet the criteria of effective teaching in both fields of robotics and environmental studies. What topics should the former, effective teaching in robotics, cover around Science, Engineering, and Technology, which are component fields of STEAM? It should also deliver skills of creativity, motivation, and problem-solving. Lastly, it should deliver interest, satisfaction, motivation, and attitudes that are complementary to robotics and technology generally (Conde et al, 2021; Darmawansah et al., 2023).

In what areas should the latter, effective teaching in environmental subjects, have common learning outcomes? Learners should gain knowledge about the environment, such as marine ecosystems, their structure, significance, and challenges. They should also develop skills, such as observation, collaboration, planning, and evaluating. Lastly, they should also develop positive attitudes, such as concern about the environment and interest in learning more about risks that threaten it and the possible solutions to those issues. There are certainly common points in the learning outcomes of STEAM and environmental education (Ruiz Vicente et al., 2020; Texeira et al., 2018; Talib et al., 2020; Ziouzios et al., 2021). Bearing in mind the above, the research questions of the study are:

1. Can STEAM bring about effective learning outcomes regarding marine environments?
2. Can such a teaching intervention have a long-lasting impact on the schools and their functions?

By answering these questions, it is possible to decide upon the feasibility of efficiently executing an innovative activity such as ROBOAQUARIA, leading to the improvement of school functions. The first research question, which concerns learning outcomes, refers to knowledge, skills, and attitudes that would be promoted. The second research question concerns the way pedagogies, infrastructure, teachers' competencies, and professional development are influenced and changed through the program (Conde et al., 2021; Darmawansah et al., 2023; Fullan, 2007; Kalaitzidou & Pachidis, 2023).

Data Collection and Analysis

The data for the study derives from reports submitted by each participant country at the end of every year that include information regarding the implementation and impact of the project. The formal procedure regarding the structure, content, and submission of these reports was determined in the application and initial plan of the ROBOAQUARIA project. Each report contains detailed information regarding the sample of the organization and the members who participated in the activities. The reports provide insights into the context of the organizations, their experience with STEAM, innovation, and the pedagogical practices that are usually implemented, and how they compare to the ones involved in the project. Moreover, the partners that completed the reports were expected to mention, among other data, whether there are detectable practices that can be adopted by the school and if there are available or accessible resources and manageable costs. Besides that, the reports provide a detailed description of how the implementation of activities took place, the learning outcomes, the benefits for the school, the advantages, and the possible risks.

A total of 25 organizations from all participating countries were included, including schools of different ages and levels, universities, research centers, and organizations, all of them involved in STEAM education.

The analysis was based on a qualitative approach. The answer to the first research question derived from data directly related to the implementation description and the learning outcomes. The answer to the second research question was derived from data regarding the impact on schools, resources, costs, and potential permanent adoption of the program's pedagogies and strategies. The data from the reports were coded, and two nodes were selected. The first one was *Learning Outcomes;* it addressed the first research question and contained nodes such as "knowledge", "skills", and "attitudes". The second one was *Impact;* it addressed the second research question and contained nodes such as "pedagogies", "infrastructure", and "teachers' competencies & professional development". These nodes were selected as according to Conde et al (2021), Darmawansah et al (2023), and Kalaitzidou & Pachidis (2023), they are the main topics related to STEAM and Robotics teaching. Each phrase, text, and part of the report was related to a specific code and node, depending on its content. Once the coding was completed, the nodes and codes were gathered and analyzed (Cohen et al., 2017).

Findings and Discussion

The results of coding, as presented in Table 1, show that all codes and nodes have been identified in the data.

The first research question concerns the areas in which the codes of the category *Learning Outcomes* were identified. Data from the reports supports the fact that implementation of the program can lead to significant learning outcomes. Some report comments could be classified under the code "knowledge", as they indicated possible cognitive outcomes. As mentioned in a participant report, knowledge gained from the project can be about digital technologies and robotics, because learners can better understand these concepts through the program. The knowledge can also be about Science through an interdisciplinary approach. These report comments, which are classified under the code "skills", referred to psychomotor outcomes such as competencies to carry out projects. Along with that, the importance of project-based learning and problem-solving approaches is frequently highlighted. There were report comments classified under the code "attitudes" that referred to affective outcomes, such as positive views, ideas, and motivation towards using technologies within environmental projects.

Table 1

Codes and Nodes (categories), Frequency, and Exemplary Quotes Identified in the Reports

Nodes & Codes	Frequency/entries	Report Comment Quotes
Node: Learning Outcomes	133	*".... present a comprehensive view of the world of water, through clear and interesting displays, informed, helpful staff, and exciting live presentations"*
• **Code: Knowledge**	58 (43.6%)	*"Utilize technology, such as coding, robotics, and digital storytelling, to engage students in interdisciplinary activities"*
• **Code: Skills**	46 (34.6%)	"*Encouraging skills, such as creative and logical thinking, problem-solving, and collaboration is a workable practice….These skills are essential in a global context and can be integrated into curricula worldwide"*
• **Code: Attitudes**	29 (21.8%)	"*Teachers and students must be adept at utilizing digital tools for tasks, such as data gathering, analysis, and managing robotic systems*"
Node: Impact	74	*"by leveraging project-based learning as a central methodology for the school*"
• **Code: Pedagogies**	27 (36.5%)	*"The project seeks to promote education uptake by making learning more engaging and relevant*"
• **Code: Infrastructure**	22 (29.7%)	"*Funds: Budget for robotics components, tools, and technical support. Facilities: Lab space for robot development and testing"*
• **Code: Teacher competencies and professional development**	25 (33.8%)	"*The program will offer teachers guidance on robotics, engineering, and marine environment*' or '*Providing teacher training, including lesson plan implementations, Learning, Teaching, and Training Activities (LTTA), e-learning toolkits, and guidelines for educators.*"

Addressing the concerns of the second research question, there were various codes related to the category *Impact*. The code "pedagogies" was used to classify report comments in which the new approach is described as important, not only for the project but for the entire learning organization. Emphasis is given to pedagogies that relate to ethical and legal considerations, which are included in activities. The code "infrastructure" was used to classify report comments that relate to the schools' infrastructure, that is, the existence and use of tools, such as robotic kits and programming software. Finally, the code "teacher competencies" was used to describe report comments that imply that teachers will develop competencies and build knowledge from the program.

These report comments show that the program, which engages STEAM in teaching about marine ecosystems, is considered efficient. They also demonstrates that educational contexts are generally able to implement such relevant projects. The project is indeed an opportunity for the construction of new knowledge in Science, Robotics, and how technologies can assist in dealing with environmental challenges. There is a common belief that the most suitable approach for the project is through project-based teaching with hands-on activities. This can help learners actively engage and develop competencies, skills, and attitudes that will help learners deepen their understanding of the new knowledge and increase their motivation to study it further. This can enhance the possibility of relevant innovation to succeed (Conde et al., 2021; Darmawansah et al., 2023; Kalaitzidou & Pachidis, 2023).

The impact of the program on the school seems to be understood as significant too. The benefits for the school community are likely to go beyond the implementation of the program. As the participants pointed out in their reports, there is an emphasis on the enrichment of the school equipment. The schools will obtain equipment that can be used by educators in activities that can help learners further understand how robotics and modern technology can be used in favor of the marine environment, assist in their studies, and deal with relevant challenges. Apart from that, the provision for the professional development of teachers and members of the school community is also apparent and significant. This professional development focuses on technical matters, such as learning about robotics and equipment that can help with studying marine environments. It also focuses on pedagogical matters, such as analyzing lesson plans, syllabi, and curricula in which the equipment can be used. Project-based activities are frequently mentioned and are noted as appropriate and necessary for teachers to become more confident, which is highly possible thanks to the program. In short, teachers will become familiar with using the relevant technologies and will implement effective educational activities as part of their work. Thanks to these points, the program can generally induce a shift in the schools (Conde et al., 2021; Darmawansah et al., 2023; Fullan, 2007 Kalaitzidou & Pachidis, 2023).

Conclusions

The main finding of this study is that STEAM and Robotics can be used to teach about marine environments. This is justified by the reports of the project ROBOAQUARIA, which is innovative because of its mission and structure, as it includes participants from different countries. The teachers and the rest of the education industry express positive attitudes, comments, and ideas towards such innovations. Their advantages are significant. Firstly, they can lead to learning outcomes, as the students can gain knowledge, develop skills, and adopt friendly attitudes. These can be used to address the marine environment's ecosystems, conditions, and characteristics. They can also be used to address STEAM, robotics, design, and programming. The integration of the two fields can help students better understand how technologies can be used to aid understanding of marine environments and take better action towards their support and preservation. These findings are compatible with those of other projects that integrated STEAM and environmental study (Ruiz Vicente et al., 2020; Texeira et al., 2018; Talib et al., 2020; Ziouzios et al., 2021).

Secondly, the participants expressed that the project had a greater positive impact on the school community. The main reason is its holistic approach, which combines the provision of equipment, instructions, lesson plans, syllabus, curriculum, teacher training, and guidance. Thanks to this, the teachers and the school can become more familiar with project-based activities, cooperation, and innovation. These are competencies that the teachers believe they can gain from the project and described as crucial and useful for their work. This is also verified by literature as important (Conde et al., 2021; Darmawansah et al., 2023; Fullan, 2007).

In short, teachers and schools are willing to implement activities that combine robotics teaching in the context of marine environments and they support its necessity. Nevertheless, it is important to note that this study is derived from a single project. Before generalizing this conclusion, such a limitation should be taken into consideration (Cohen et al., 2017).

References

Christidi, Z., & Christopoulou, E. (2022). *Environmental awareness in preschool education via educational robotics and STEAM education*. In 2022 7th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM) (pp. 1-8). IEEE.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education* (8th ed.). London: Routledge.

Conde, M. Á., Rodríguez-Sedano, F. J., Fernández-Llamas, C., Gonçalves, J., Lima, J., & García-Peñalvo, F. J. (2021). Fostering STEAM through challenge-based learning, robotics, and physical devices: A systematic mapping literature review. *Computer Applications in Engineering Education*, *29*(1), 46–65. https://doi.org/10.1002/cae.22354

Darmawansah, D., Hwang, G.-J., Chen, M.-R. A., & Liang, J.-C. (2023). Trends and research foci of robotics-based STEM education: A systematic review from diverse angles based on the technology-based learning model. *International Journal of STEM Education*, *10*(12). https://doi.org/10.1186/s40594-023-00400-3

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York, NY: Teachers' College Press.

Kalaitzidou, M., & Pachidis, T. P. (2023). Recent robots in STEAM education. *Education Sciences*, *13*(3), 272. https://doi.org/10.3390/educsci13030272

Kanaki, K., & Kalogiannakis, M. (2023). Fostering computational thinking and environmental awareness via robotics in early childhood education: A scoping review. *Research on Preschool and Primary Education*, 39–50. https://doi.org/10.55976/rppe.12023217739-50

Ruiz Vicente, F., Zapatera Llinares, A., & Montés Sánchez, N. (2020). "Sustainable City": A steam project using robotics to bring the city of the future to Primary Education students. *Sustainability*, *12*(22), 9696. https://doi.org/10.3390/su12229696

Talib, C. A., Aliyu, H., Aliyu, F., Maimun, A., Malik, A., Anggoro, S., & Ali, M. (2020). Integration of robotics into STEM education for facilitating environmental sustainability. *Solid State Technology*, *63*, 767–783.

Teixeira, M. A. S., Santos, H. B., Dalmedico, N., de Arruda, L. V. R., Neves, F., & de Oliveira, A. S. (2018). Intelligent environment recognition and prediction for NDT inspection through autonomous climbing robot. *Journal of Intelligent & Robotic Systems*, *92*(2), 323–342. https://doi.org/10.1007/s10846-017-0764-6

Ziouzios, D., Rammos, D., Bratitsis, T., & Dasygenis, M. (2021). Utilizing educational robotics for environmental empathy cultivation in primary schools. *Electronics*, *10*(19), 2389. https://doi.org/10.3390/electronics10192389

Author Details

Konstantinos Karampelas
University of the Aegean
Greece
kkarampelas@aegean.gr

Nancy Pyrini

University of the Aegean
Greece
nancypyrini@aegean.gr

George Sarrigeorgiou
University of the Aegean
Greece
gsarrigeorgiou@gmail.com

Laura Screpanti,
Università Politecnica delle Marche
Italy
l.screpanti@staff.univpm.it

Benedetta Castagna,
Università Politecnica delle Marche
Italy
b.castagna@staff.univpm.it

David Scaradozzi
Università Politecnica delle Marche
Italy
d.scaradozzi@univpm.it

Ana Sović Kržić
University of Zagreb
Croatia
ana.sovic.krzic@fer.hr

ARISTARCHUS—ARTISTIC REALITY IN SCHOOL EDUCATION: ENACTED, REFLECTIVE AND COLLABORATIVE LEARNING WITH THE HUMAN ORRERY SPACE

Konstantinos Karampelas, Anastasia Pyrini, George Sarrigeorgiou and Konstantinos Tsolakidis
University of the Aegean
GREECE

Emmanuel Rollinde
Université de Cergy-Pontoise, LDAR - Laboratoire de Recherche
FRANCE

Malte Ubben and Maximilian Alexander Loch
University of Münster
GERMANY

Nicoletta Pantela
Center for the Advancement of Research and Development in Educational Technology
CYPRUS

Abstract

This study explores the effectiveness of a human orrery for astronomy education through the ARISTARCHUS project, which involves a consortium of four organizations across France, Cyprus, Germany and Greece. Astronomy education is crucial yet challenging due to its abstract concepts. The orrery fosters active learning and mental modeling. Projects employing orreries demonstrate significant learning outcomes, enhancing students' comprehension and attitudes towards astronomy. The ARISTARCHUS project aims to revolutionize astronomy education, promoting active learning, interdisciplinary approaches, and sustainable teaching methods across different educational systems. Evaluation through tests and teacher reports indicates promising results, suggesting a potential for transformative impacts on schools.

Introduction

This paper is a study around the use of a human orrery (a heliocentric model of the solar system) for teaching astronomy. It is based on implementing the project *ARISTARCHUS—Artistic Reality In School Education: Enacted, Reflective and Collaborative Learning with the Human Orrery Space*. The project belongs to the category of ErasmusPlus actions and is funded by the European Union. It consists of a consortium of four organizations from four countries: France, Cyprus, Germany and Greece.

Astronomy has been a major unit in science for decades. Many Nobel prizes in Physics have been awarded to scientists who are specialized in astronomy. Learners of all ages will be involved in teaching activities that involve astronomy. Even though the unit has been considered attractive, it is still considered challenging because of concepts, terms, formulas, and highly complex mathematical patterns that learners do not encounter in their everyday lives. Indeed, as with other concepts and topics of science, in astronomy, learners develop false ideas and misconceptions, which persist and prevent the understanding of actual scientific facts regarding topics such as the planets, their motion and the solar system. Teachers and schools can overcome these barriers by designing, selecting, and using appropriate tools and equipment. These tools will assist learners engaging in astronomy activities. They should motivate active participation and learning by doing, so that the misconceptions of learners will be tested, challenged, and rejected. They should be easy to use in the classroom or any teaching room in the school or otherwise. The phenomena, concepts, and basic knowledge of astronomy should be presented in a simple, easy-to-understand yet accurate and scientifically justified way, with the help of these tools (Salamah et al., 2022; Bitzenbauer et al., 2023). For schools to adopt this approach to astronomy teaching, it is necessary to implement relevant programs that can assist in establishing sustainable, feasible and relevant teaching approaches that schools can use regularly (Fullan, 2007).

This paper presents such a program, a project called ARISTARCHUS. It starts with a literature review around the teaching of astronomy, discusses mental modeling by presenting similar projects that have already been published, and moves on to the methodology, describing the project and its characteristics. It then ends with the findings and conclusions. The structure follows strictly the common outline of education research (Cohen et al., 2017).

Literature Review

To examine the potential of a project to promote effective astronomy teaching, examining the main relevant research findings and the context of the project is necessary.

Astronomy Teaching and Modeling

Astronomy education is inherently multifaceted, typically emphasizing key topics such as the Earth's orbit around the Sun, seasonal variations, and the solar system's composition and dynamics, including planetary interactions with the Sun (Lelliott & Rollnick, 2010). These foundational concepts, integral to astronomy teaching for decades, are fundamental to understanding celestial phenomena. Mental or physical models play a pivotal role in enhancing astronomy learning. Mental model building allows learners to conceptualize astronomical ideas, facilitating comprehension and inquiry into complex phenomena. Such models are aligned with contemporary pedagogical approaches, fostering familiarity and enabling learners to employ similar techniques across various disciplines. In this educational framework, students engage in tasks and activities carefully curated to enhance comprehension and construct knowledge. First, learners grasp the educational purpose of the model, drawing from their experiences and ideas to contextualize their learning. Second, learners compare and contrast their mental models with others encountered previously, advancing scientific discourse and deeper understanding. Third, learners actively participate in inquiry-based activities facilitated by models, conducting observations, collecting data, and testing hypotheses under their instructor's guidance (Taylor et al., 2003).

The human orrery emerges as a valuable tool in astronomy education, facilitating mental modeling and active learning. It dynamically portrays the solar system's complexities, offering opportunities for interactive and outdoor activities. Learners experiment, calculate, and discourse around planetary motion, orbits, and celestial mechanics. By manipulating the orrery, learners gain insights into astronomical phenomena, such as variations in planetary rotation around the Sun and the dynamics of comets and meteorites (Asher et al., 2006).

The orrery's interactive nature encourages deeper engagement compared to passive instruction methods, enhancing learners' comprehension and retention of astronomical concepts. By actively participating in learning activities facilitated by the orrery, students develop a nuanced understanding of celestial phenomena, transcending rote memorization. This active learning approach aligns with contemporary educational paradigms, emphasizing experiential learning and critical inquiry (Taylor et al., 2003).

The integration of human orrery into astronomy education offers a dynamic and effective approach to teaching complex celestial phenomena. By fostering active learning and mental modeling, students engage deeply with astronomical concepts, promoting comprehension and retention. This pedagogical approach, rooted in interactive learning and scientific inquiry, enhances astronomy education and inspires future generations of astronomers (Taylor et al., 2023; Asher et al., 2006).

The Human Orrery in Astronomy Teaching

Several projects have successfully integrated human orreries into astronomy education, demonstrating their effectiveness in enhancing learning outcomes. Rollinde (2019) conducted a study in France, where a printed orrery was utilized to teach 14-year-old students concepts of mathematics and physics of planetary motion within the solar system. The intervention centered on facilitating an understanding of velocity, space, time, inertia, gravity, and other relevant principles through active questioning and sensorimotor engagement. Learners interacted with the orrery, gaining a deep understanding of astronomical phenomena, thereby achieving cognitive goals while expressing a heightened interest in astronomy.

Similarly, Newbury (2010) implemented an astronomy teaching program for undergraduate students, incorporating sessions based on orreries. Students actively participated in constructing their orreries, engaging in mathematical calculations related to planetary characteristics and orbits. Through observational activities and hypothetical scenarios, students developed a nuanced understanding of the solar system's dynamics and astronomical laws. The interactive nature of orreries facilitated learner involvement and interaction, with positive learning outcomes.

Sansone et al (2019) utilized a human orrery in didactic laboratory activities for high-school students in Italy, focusing on understanding the solar system's scale and characteristics. Through collaborative tasks and hands-on exploration, students gained significant astronomical knowledge and developed skills in data interpretation and analysis. The orrery served as a mental model, for students to construct knowledge actively and engage in scientific discourse, fostering enthusiasm and deeper learning.

Lebofsky et al. (2011) conducted a project aimed at modeling the solar system using human orreries, involving participants from scout groups in Arizona, USA. By constructing orreries and engaging in astronomy discussions, participants gained insights into celestial phenomena and astronomical principles. The hands-on nature of the activity promoted active learning and enthusiasm among participants, highlighting the value of orreries in astronomy education.

These projects collectively underscore the benefits of using an orrery in astronomy education, providing opportunities for active participation, knowledge construction, and skill development. The hands-on approach fosters engagement and enthusiasm among learners, facilitating a deeper understanding of astronomical concepts and phenomena. By involving students in the design and construction of orrery, educators promote deeper engagement and comprehension, aligning with the principles of active learning and mental modeling in astronomy education (Taylor et al., 2003).

In conclusion, using orreries in astronomy teaching promises to engage students and enhance learning outcomes. Through hands-on activities, collaborative tasks and interactive exploration, students develop a deeper understanding of astronomical knowledge. Educators should prioritize student involvement in orrery design and construction, fostering active learning and enthusiasm for astronomy. Evaluation of such interventions should encompass observations and pre/post-tests to assess learning outcomes, ensuring the efficacy of orrery-based teaching approaches (Newbury, 2010; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019). This approach not only promotes knowledge acquisition but also nurtures essential skills and attitudes conducive to lifelong learning in astronomy (Taylor et al., 2003).

ARISTARCHUS Project: The Context of the Study

Using a human orrery in astronomy teaching has been endorsed by previous studies (Asher et al, 2006; Newbury, 2010; Lebofsky et al, 2011; Rollinde, 2019; Sansone et al., 2019). In line with this, the ARISTARCHUS project was developed, aiming to achieve four primary goals: engagingly exploring fundamental laws of physics and mathematical concepts; fostering learners' scientific knowledge in Science, Technology, Engineering, Arts and Mathematics (STEAM) disciplines for modern scientific engagement; enhancing interdisciplinary STEAM learning and student well-being; and improving learners' scientific process skills. The project encompasses four work packages with specific deliverables, alongside teaching interventions. These interventions involve the design, development, and utilization of human orreries, a methodological framework, an educational toolkit, an augmented reality application, and an e-learning platform with gamified modules.

Three teaching interventions were implemented. To build knowledge of astronomy and the solar system, the first intervention focused on learning to use the orrery. The second addressed the orbital period of each planet around the sun, highlighting their individual rotational times. The third intervention explored concepts of day and night.

Notably, the project demonstrates innovation and significance in several dimensions. It operates across four countries with diverse educational systems, managed by a consortium of educational and research organizations. Additionally, it caters to learners of various ages and educational levels, employing a holistic approach that includes lesson-plan preparation and material development for astronomy education. The project emphasizes active student participation through project-based learning activities, including student involvement in orrery design. By prioritizing these aspects, the project aims to be innovative and effective (Asher et al., 2006; Fullan, 2007; Newbury, 2010; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019).

Methodology

To evaluate the potential of a project such as ARISTARCHUS to have the desired learning outcomes and impact on schools, selecting appropriate research questions, data collection, and data analysis methods is necessary (Cohen et al., 2017).

The Research Questions

As the project examines the potential learning benefits of using an orrery in astronomy teaching, the research questions should relate to what the appropriate learning benefits are and how they can be achieved. At first, the role of orrery as a means for mental modeling should be emphasized. It is necessary to evaluate whether learners developed visualizations and representations of the planetary system and used them in scientific discourse, to study, understand, explain, and hypothesize regarding planets, the sun, their position, motion, orbit, and other concepts of astronomy. Mental modeling is essential (Taylor et al., 2003; Asher et al., 2006). Second, the sustainability of this project and the general impact on the schools should be emphasized. It is necessary to evaluate whether this project can help transform the way schools work, so that they can embed the use of an orrery. This implies that teachers and members of educational organizations agree on the significance of using an orrery and are not discouraged by its challenges, such as lack of space, time, and relevance to the school curriculum or syllabus (Fullan, 2007; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019). Bearing in mind the above, the research questions are formed as follows:

1. Did the orrery help the learners develop mental models around the astronomy concepts studied?
2. Did the project help a greater change in the schools?

Data Collection and Analysis

The data for the first research questions were collected through questionnaires. A total of 200 students who took part in the project filled in a questionnaire before and after the teaching interventions. It was based on *Sustainable Development Goals for Quality Education* (Saini et al., 2023), as this tool was considered suitable for the goals of the project. The questionnaires, as presented in Table 1, included statements to which students had to express agreement or disagreement, through a Likert scale, with numbers from 1 to 4. The statements had information regarding the knowledge obtained from the instructions (questions 12–15), the skills that learners developed (Questions 4, 5, 6, 7, 8, and 11) and the attitudes they adopted (Questions 1, 2, 3, 9, and 10). Analysis was based on the classification of answers into pairs. The responses to a question were classified as negative if students responded with a 1 or 2 on the scale, or positive if students responded with a 3 or 4. The number of each country's negative and positive answers was calculated and summed up. This helped compare responses before and after the teaching activities. This method with pre-tests and post-tests is common for projects using an orrery (Newbury, 2010; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019).

Table 1

The Qestionnaire That Learners Filled in Before and After The Implementation of Activities (pre- and post-test), in Correspondence with SDG Targets

Goal	Questions
Interest for science (Attitudes, affectionate goals)	Q1 Rate how much you liked the science lessons. Q2 Rate how comfortable you felt in the science lessons. Q9 Rate how much you have maintained your interest in your science lessons.
Novelty for science (Skills, psychomotor goals)	Q6 I discovered new science in the science lessons. Q11 I feel like I have learned new ways of discovering the world in the science lessons.
Active citizenship (Attitudes, affectionate goals)	Q3 Rate how important you felt your actions in the science lesson were. Q10 I understood what to do in the science lessons.
Appreciation of others (Skills, psychomotor goals)	Q4 Rate how much you helped others in your science lessons. Q5 Rate how much working with others helped you to better understand science lessons. Q7 Rate your degree of connection with your peers in science classes. Q8 I took help from others in the science lessons.
Universal literacy (knowledge, cognitive goals)	Q12 I can explain why Earth is a special place in the universe. Q13 I can explain why there is day and night. Q14 I can explain what a year in the solar system is. Q15 I know many different objects in the solar system.

The data for the second research question were collected from reports of teachers. A total of 14 reports were completed, as decided upon with the initial plan of the project. Within these reports, teachers explained the impact of the project on learners, teachers, leaders, and partner organizations. The impact could be relevant to challenges in the implementation of new pedagogies and shifts in functions and infrastructure. Analysis was done through a qualitative approach that relied on coding. Parts of the report were classified into codes, depending on their content. The codes were gathered and analyzed as in qualitative research (Cohen et al., 2017). The codes were "*Learners*", "*Teachers"*, "*Leaders"*, "*Challenges*", "*Functions*", "*Pedagogies*" and "*Infrastructure*". Their selection was based on the main literature regarding the use of the orrery as an activity of mental modeling in astronomy from schools (Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019).

Findings and Discussion

The findings show that the learning outcomes from implementing the study were significant. In what concerns the first research question, as seen in Table 2, the learners expressed that they achieved cognitive goals to a significant extent. The data are presented in sets. The first set shows the number of participants giving negative answers (1 or 2) as opposed to the number of participants giving positive answers (3 or 4) in the pre-test. The second shows the number of participants giving negative answers (1 or 2) as opposed to the number of participants giving positive answers in the post-test.

Table 2

Percent Positive Responses to Questions (selection of "3" or "4" on a Likert Scale of 1-4)

		France		**Greece**		**Cyprus**		**All**	
	Number of participants	**58**		**60**		**79**		**197**	
	Question	Pre-test %	Post-test %	Pre-test %	Post-test %	Pre-test %	Post-test %	Pre-test %	Post-test %
Interest in Science (Aattitudes)	**Q1—like**	84.48	91.38	93.33	86.67	75.95	84.81	82.50	86.00
	Q2—comfortable	84.48	86.21	66.67	83.33	83.54	92.41	77.50	86.50
	Q9—interest	62.07	63.79	71.67	86.67	72.15	91.14	68.00	80.50
Novelty of Science (Skills)	**Q6—new science**	89.66	93.10	81.67	90.00	79.75	88.61	82.00	89.00
	Q11—new ways	87.93	89.66	65.00	86.67	81.01	73.42	77.00	81.00
Active citizenship (Attitudes)	**Q3—importance**	75.86	79.31	71.67	86.67	81.01	97.47	75.50	87.50
	Q10—understanding	74.14	53.45	60.00	58.33	51.90	68.35	60.00	60.00
Appreciation of others (Skills)	**Q4—help other**	81.03	81.03	71.67	85.00	72.15	82.28	73.50	81.50
	Q5—work with other	63.79	56.90	63.33	83.33	73.42	77.22	66.50	72.00
	Q7—peer connection	29.31	18.97	25.00	43.33	31.65	34.18	28.50	32.00
	Q8—took help	67.24	79.31	83.33	83.33	70.89	86.08	72.50	82.00
	Q12—Earth	81.03	82.76	60.00	86.67	68.35	87.34	68.50	98.00

Universal literacy (knowledge)	**Q13—day/night**	51.72	72.41	43.33	71.67	46.84	75.95	46.50	72.50
	Q14—a year	56.90	70.69	61.67	83.33	51.90	87.34	55.50	80.00
	Q15—objects	84.48	91.38	93.33	86.67	75.95	84.81	82.50	86.00

Knowledge such as the use of the orrery, the solar system, the rotation of each planet around the sun, and the transition from day and night was improved thanks to the activities implemented. In fact, as the data reveals, the number of students who answered in the negative in the pre-tests was almost double that in one of the post-tests. This trend appears in every country. This shows that the number of students more familiar with this knowledge rose. They also developed interpersonal skills, such as cooperation with others within teamwork as well as the exchange of assistance and ideas. Last, the learners adopted positive attitudes, such as the motivation to learn more about science and to use it as a means to become better citizens.

The findings justify that the use of a human orrery can indeed assist in learning about astronomy through mental modeling. First, students have expressed confidence that their *knowledge* has increased significantly, as they have understood and can explain certain astronomical topics, concepts, or phenomena. Second, they have gained *skills* that can be used in studying astronomy, such as visualization of the solar system and the position of the sun and planets' orbits. Third, they have also adopted positive *attitudes*, such as increased motivation to learn more about this field. The learning outcomes justify the effectiveness of the implementation. This finding is compatible with others gained from similar studies (Taylor et al., 2003; Newbury, 2010; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019).

Concerning the second research question, as can be seen in Table 3, there were plenty of report comments classified according to the determined codes. The code "*Learners"* was used to classify report comments that verify the positive learning outcomes. The code "*Teachers*" was used frequently as well, in report comments which show that the teachers had benefited from the project, by gaining knowledge or increasing motivation to learn further about astronomy and the way to teach it. For report comments that showed approval and support on behalf of head teachers, the code "*Leaders*" was also used. The code "*Pedagogies*" was used to classify quotes, which show that teachers appreciate that the orrery supports active learning through project-based activities. The code "*Functions*" was used for report comments that show that the schools started adopting innovative activities. Moreover, it was used for report comments that demonstrate that the program can serve as an opportunity to cooperate with other schools and build partnerships. The code "*Infrastructure*" was used mainly to classify reports comments focused on the benefits of having an orrery and using it to teach astronomy. Finally, the code "*Challenges*" was used to classify report comments in which the participants generally described several barriers to fitting the activities within the structured school program.

Therefore, through the reports, teachers express that the program can have an important impact on schools. Students benefit, thanks to the learning outcomes. Teachers also benefit, gaining guidance, training and familiarity with new approaches to teaching through an orrery and mental modeling. The greater school community benefits too, with opportunities for new modes of work and cooperation. Even though fitting the activities within the school schedule is challenging, the overall response is positive and receptive towards the project. These claims lead to the conclusion that the project can lead to a greater shift in schools (Asher et al., 2006; Fullan, 2007).

Table 3

Codes, Frequencies and Exemplary Quotes from the Reports

Codes	Frequency	Exemplary Quotes
Learners	32	"The whole class actively participated and most of the class quickly learned the names of the planets in English." "'I never thought I could learn about the stars by jumping around in the yard,' said a sixth-grader."
Teachers	28	"They said that they themselves learned interesting things about the planetary system. They understood phenomena such as the presence of the aurora and the aperitif that they were unaware of." "Also, most of the other teachers in the school showed interest, and some asked if they could participate in the program next year."
Leaders	16	"The school principal applauded the project and praised the effort of the students ….".
Pedagogies	22	"The engagement of students in STEAM activities was very much active." "… to begin with pupils' preconceptions and, … to provide them with the utmost opportunity to take active responsibility for their own learning; Use of the orrery in the classroom makes it possible …".
Functions	19	"…the Human Orrary (HO) is drawn and painted in our schoolyard, … many students will be willing to explore our solar system and teachers will use it as a point of reference in the future." "We also participated in the construction of the HO at the [another school]. Finally, we will help in the construction of the HO in the [another school]"
Infrastructure	16	"The HO is a helpful tool to raise awareness of STEAM and to either introduce or reinforce concepts of maths and science".

Codes	Frequency	Exemplary Quotes
Challenges	17	"The main difficulty is to find the time to teach them how to use a human orrery. This could be done outside of normal learning time but it depends on the choices made by the hierarchy at several levels." "The timetable and course syllabus limits the time available."

Conclusions

The study explores the effectiveness of a human orrery for teaching astronomy, focusing on the ARISTARCHUS project funded by the EU. Astronomy teaching faces challenges due to complex concepts and misconceptions. Tools such as the human orrery aim to engage learners practically, facilitating active participation and challenging misconceptions through mental modeling. Projects utilizing human orreries have shown positive results in enhancing astronomy learning, fostering deeper understanding and promoting student engagement. These projects emphasize the importance of learners' active participation, including the design of orreries themselves (Newbury, 2010; Lebofsky et al., 2011; Rollinde, 2019; Sansone et al., 2019). The ARISTARCHUS project, implemented across four countries, aims to explore fundamental physics laws, improve learners' STEAM knowledge, and enhance scientific process skills. Teaching interventions involve the design and use of human orreries, coupled with project-based learning activities. Evaluation of the project's impact focuses on assessing learners' development of mental models in astronomy and examining the potential shift in schools' approaches to teaching. Data analysis from pre- and post-tests and teacher reports indicates positive learning outcomes, with learners demonstrating increased understanding, skills development, and positive attitudes towards science. Teachers also report benefits from the project, including knowledge and motivation for innovative teaching methods. Despite the challenges observed, overall responses are positive and suggest a potential for broad changes in educational practices (Taylor et al., 2003; Asher et al., 2006; Fullan, 2007).

Future research could compare studies with alternative teaching methods, analyze cross-cultural influences, and develop teacher training programs (Cohen et al., 2017).

References

Asher, D. J., Bailey, M. E., Christou, A. A., & Popescu, M. D. (2006). The human orrery: A new educational tool for astronomy. *Astronomy Education Review*, *5*(2), 159–176. https://doi.org/10.3847/aer2006024

Bitzenbauer, P., Navarrete, S., Hennig, F., Ubben, M. S., & Veith, J. M. (2023). Cross-age study on secondary school students' views of stars. *Physical*

Review Physics Education Research, *19*(2), 020165. https://doi.org/10.1103/physrevphyseducres.19.020165

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education* (8th ed.). London: Routledge.

Fullan, M. (2007). *The new meaning of educational change*. (4th ed.). New York, NY: Teachers' College Press.

Lebofsky, L. A., Mc Carthy, D. W., Higgins, M. L., & Lebofsky, N. R. (2011). A Portable/Traveling Human Orrery. In J. B. Jensen, J. G. Manning, and M. G. Gibbs (Eds.), *Earth and space science: Making connections in education and public outreach 443. Cosmos in the Classroom 2010* (pp. 63-67). Astronomical Society of the Pacific Conference Series: Proceedings of a conference held at the University of Colorado, Boulder, Colorado, USA, 31 July–4 August 2010. Astronomical Society of the Pacific.

Lelliott, A., & Rollnick, M. (2010). Big ideas: A review of astronomy education research 1974–2008. *International Journal of Science Education*, *32*(13), 1771–1799. https://doi.org/10.1080/09500690903214546

Newbury, P. (2010). Exploring the solar system with a human orrery. *The Physics Teacher*, *48*(9), 573–577. https://doi.org/10.1119/1.3517019

Rollinde, E. (2019). Learning science through enacted astronomy. *International Journal of Science and Mathematics Education*, *17*(2), 237–252. https://doi.org/10.1007/s10763-017-9865-8

Saini, M., Sengupta, E., Singh, M., Singh, H., & Singh, J. (2023). Sustainable development goal for quality education (SDG 4): A study on SDG 4 to extract the pattern of association among the indicators of SDG 4 employing a genetic algorithm. *Education and Information Technologies*, *28*(2), 2031–2069. https://doi.org/10.1007/s10639-022-11265-4

Salamah, A., Prastowo, T., & Hariyono, E. (2022). The development research: Assessment instruments of science literacy based on minimum competency assessment (AKM) level 4th for solar system concepts. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *8*(1), 115–124. https://doi.org/10.21009/1.08111

Sansone, S., Marocchi, D., & Rinaudo, M. (2019). Astronomy laboratory for 13-to-15-year-old students. *Journal of Physics: Conference Series*, *1286*(1), 012012. https://doi.org/10.1088/1742-6596/1286/1/012012

Taylor, I., Barker, M., & Jones, A. (2003). Promoting mental model building in astronomy education. *International Journal of Science Education*, *25*(10), 1205–1225. https://doi.org/10.1080/0950069022000017270a

Ubben, M. S., Loch, M., & Rollinde, E. (2024). Exploring effects of embodied learning on students' perception of astronomy and science. manuscript submitted for publication. *Journal Not Specified for Possible Open Access Publication under the Terms and Conditions of the Creative Commons Attri- Bution* (CC BY) License https://Creativecommons.Org/Licenses/by/4.0/

Author Details

Konstantinos Karampelas
University of the Aegean, Rhodes,
Greece
kkarampelas@aegean.gr

Nancy Pyrini
University of the Aegean, Rhodes, Greece
nancypyrini@aegean.gr

George Sarrigeorgiou
University of the Aegean, Rhodes, Greece
gsarrigeorgiou@gmail.com

Konstantinos Tsolakidis
University of the Aegean, Rhodes, Greece
tsolak@aegean.gr

Emmanuel Rollinde
Université de Cergy-Pontoise, ESPE de Versailles, LDAR, Paris, France,
emmanuel.rollinde@cyu.fr

Malte Ubben
Institut für Didaktik der Physik, University of Muenster
Germany
malte.ubben@uni-muenster.de

Maximilian Alexander Loch
Institut für Didaktik der Physik, University of Muenster
Germany
maximilian.loch@uni-muenster.de

Nicoletta Pantela
Center for the Advancement of Research and Development in Educational Technology, Nicosia
Cyprus

nicoletta.pantela@cardet.org

EMPOWERING SUSTAINABLE EDUCATION: REFLECTIONS FROM THE MIRACLE PILOT INITIATIVES

Orestes Varonis, Evangeline Varonis, and George Sarrigeorgiou
PARAGON-eduTech
GREECE

Anastasia Pyrini and Darya Yegorina
CleverBooks
IRELAND

Abstract

The MIRACLE (coMics and IllustRations Augmented to tackle Climate change in primary Education) project, funded by Erasmus+, aims to integrate climate change education into primary schools through innovative teaching methods, including augmented reality (AR) and comic creation. This paper presents the findings from the first pilot implementation, which focused on enhancing teacher and pupil digital skills, promoting a green teaching culture, and addressing eco-anxiety. The pilot testing of the project's learning scenarios involved 365 students and 40 teachers from partner schools in Greece, Spain, Malta, Croatia, and Portugal. The project also highlights the importance of a Whole-School Approach, emphasizing active involvement from parents and the broader community. Results of pre- and post-tests are summarized, highlighting the impact of learning about climate change on knowledge, attitudes, and behaviour.

Introduction

Climate change (CC) is an urgent global issue with dangerous consequences. It requires innovative experiential approaches to teach its effects and modify attitudes in support of pro environmental actions. The MIRACLE (coMics and IllustRations Augmented to tackle Climate change in primary Education) project develops inclusive strategies for teachers and students to learn about and engage with CC, a topic that at Primary Education level is perceived as abstract, distant, and complex, and may contribute to growing feelings of sadness, hopelessness, and anxiety.

MIRACLE draws on augmented reality as a medium to educate about climate issues, directly expose users to novel stimuli, and create comics about sustainability, offering the pupils' learning experiences that are engaging, available, and impactful. Comics in education support scientific literacy (Tatalovic, 2009) and creativity, helping learners develop imagination and read between the lines. Comics with AR can also boost digital skills development (Nidhom et al, 2019).

MIRACLE also promotes the STEAM approach in primary education through interdisciplinary teaching in environmental contexts, focusing on the basic science behind CC and comics art through a partnership among six entities: 1) three primary schools located in Ireland, Croatia, and Malta; 2) two technology SMEs, CleverBooks (Ireland) and Jaitek (Spain); 3) a non-profit civil company (Greece); 4) two higher education institutions (The University of Malta and The Autonomous University of Madrid; 5) a Foundation (Fundación Siglo22, Spain); and 6) wider society. The project facilitates participation in and outside the partnership, fostering equity and equality at all levels.

Background and Rationale

Europeans rank climate change among the most serious problems facing the world today (European Commission, 2021). Protecting the environment is important to 84% of EU citizens personally; 78% consider that environmental issues impact directly on their daily lives and health and almost all feel that urgent action is needed to tackle biodiversity loss (European Commission, 2024). Putting environmental sustainability at the heart of education and training means responding to the realities of the 21st century and equipping learners with the competencies they need to contribute positively to a sustainable society and economy. Teachers and trainers across Europe are already actively teaching for sustainability, often driven by their sense of responsibility to prepare future generations. At the same time, many educators say they lack training and support in sustainability education and training, in particular, regarding interdisciplinary approaches, active pedagogies, and the challenging subject matter (Goller & Rieckmann, 2022).

Teachers need time, resources, and free professional development opportunities to provide quality climate education. They need time as part of their working day to plan, train and innovate in climate education. They need quality teaching and learning materials, which can be provided by open educational resources, and they need to develop their confidence to teach climate change science. The hope is that they will educate their students to be actively involved in local, regional, national, and European actions on environmental sustainability, and build lifelong habits that are environmentally conscious and sustainable.

The MIRACLE project develops an inclusive Digital Learning Environment (DLE) to upskill teachers' digital and sustainability competencies, empowering them to support school community members as agents of change in the spirit of the European Commission's Digital Education Acton Plan (2020). Using immersive technologies, MIRACLE creates an integrated and inclusive DLE, "The MIRACLE Augmented Classroom", which raises pupils' awareness of environment and climate change and guides behavioural changes in individual preferences, consumption habits, and lifestyles in line with: a) the New European Bauhaus initiative (Rosado-García et al, 2021); b) the European Council Recommendation on learning for environmental sustainability (European Council, 2022); and c) the "GreenComp: The European sustainability competence framework" (Bianchi et al, 2022). Teachers, mentors, school principals, school staff, parents, and the wider community (Whole School Approach) (Bryan & Henry, 2012) develop digital and sustainability competencies through innovative pedagogical practices and activity implementation.

The project is an innovative approach to ESD carried out by a multidisciplinary group of experts from five European countries, aiming to facilitate collaborative and transformative learning in order to affect change for sustainability. The project will demonstrate how education and learning coupled with multi-stakeholder engagement can effectively drive community action to tackle sustainable development challenges at the local level and help achieve European and global goals. The MIRACLE project relies upon people from all parts of the school community to achieve success.

Methodology

The MIRACLE project responds to the need for a systemic green component of education and responds to the existing challenges by:

- adopting an interdisciplinary approach to learning about environmental sustainability, putting the learner at the centre of the co-creation processes;
- providing pupils with an interactive and immersive experience with Augmented Reality of co-created digital comics, creating lasting knowledge and understanding of the topic and sparking their interest in science;
- adopting a "Whole School Approach" where sustainability is embedded in all processes and operations;
- providing schools with the basic science behind Climate Change, including data and tools on how to monitor the effectiveness of sustainability initiatives and efforts;
- mapping the national curricula for sustainability at all grades of primary education so that schools can easily integrate the project's learning activities;
- offering teachers training and support in sustainability education and training, in particular regarding interdisciplinary approaches, active pedagogies, and the challenging subject matter.

The main concrete results developed in the five Work Packages (WPs) of the project are

1. WP1: All administration, monitoring, assessment reports and tools
2. WP2: The MIRACLE Sustainability Mindset in European Schools
3. WP3: The MIRACLE MOOC
4. WP4: The MIRACLE Augmented Classroom and
5. WP5: The visual branding of the project, publications, creation of networks, info days, and multiplier events.

As part of WP3, the project will develop the "Miracle Augmented Classroom" (MAC), a flexible and innovative learning space that can enable teachers to guide pupils' discovery, facilitate their learning and the development of new skills and competencies, and promote curiosity, innovation and autonomy. The MAC will support pupils to level up their digital comic co-creations with AR, manipulate 3D models of selected topics, supported by informative videos, and participate in learning activities that culminate in community action. This method helps to create a lasting impression of the topics, and sparks learner interest in science and particularly CC.

The concrete materials of the MIRACLE project are in English with selected parts translated and adapted for Croatian, Greek, Maltese, and Spanish audiences to facilitate MIRACLE uptake and promote a shared understanding of project results in the schools.

A pilot has been administered as an exemplar for designing an effective implementation plan to gain insight into the main challenges and opportunities for the effective integration of MIRACLE in the school curriculum. This paper reviews the results of the pilot, which is intended to pave the way for further strategic actions before wide scale implementation. The opportunities afforded by international cooperation on the project include the ability to compare results internationally and determine what strategies benefit a broad number of cultural backgrounds and why. The project also provides robust opportunities for teachers rarely included in such international projects to develop leadership in CCE and STEAM teaching in an international context. Furthermore, it allows each of the partners to develop and increase their capabilities in line with the selected priorities.

Pilot Survey Design

Pilot Surveys were designed as two blind treatments (pre- and post-test) for three groups: students; teachers; and community members. Each school was assigned a unique id, and each respondent in each school received a unique personal id that was recorded for purposes of paired statistical analysis but not shared with the researchers. This paper will summarize in the aggregate the results of the pre- and post-tests for student and teacher groups from Croatia, Greece, Malta, Portugal, and Spain.

Results – Student Survey

A series of demographic questions collected information on the students' age, gender, grade level, and country. The student survey includes seven Knowledge questions, eight Attitude questions, and seven Behaviour questions, all created with a 5-point Likert Scale (1 = "Strongly Disagree"; 2 = "Disagree"; 3 = "Neither Agree nor Disagree"; 4 = "Agree"; and 5 = "Strongly Agree". There were also five open-ended questions that are not analysed here.

In order to determine the effect of training in CC, the pre-test was administered before the CC lesson, and the post-test after. The number of subjects completing the pre-test and post-test from each country are summarized in Table 1.

Table 1

Students Completing the Pre-test and Post-test in Five Countries

Country	Pre-test n	Post-test n
Croatia	50	41
Greece	110	70
Malta	74	27
Portugal	74	49
Spain	57	57
Total	*365*	*244*

Cronbach's Alpha Values were calculated for CC latent items for all five countries together, with 365 students completing the pre-test and 244 completing the post-test. Cronbach's Alpha varied from .803 to .890, with a qualitative interpretation of "Good", meaning the results are reliable.

In Croatia, Greece, Malta, and Portugal, the total of students completing the pre-test was not equal to the total of students completing the post-test. As a result, inferential statistical analysis could not be used in the combined analysis of all five countries together. However, in Spain, the same students completed both pre-test and post-test (n = 57). Therefore, student data is analyzed in two ways:

1. The first analysis combines the data from students in all five countries with all the Knowledge questions, all the Attitude questions, and all the Behaviour questions considered individually and in sets.
2. The second analysis focuses on student data from Spain and includes inferential statistics. As the same students completed both pre-test and post-

test, it was possible to implement a Non-parametric Paired-Samples Wilcoxon-Test on those results and report on levels of significance for each question within each set.

An analysis of the open-ended questions is not included here, but this information is incorporated informally in the pilot teacher reports.

Students Combined Results: Croatia, Greece, Malta, Portugal, and Spain

The combined survey results are analysed in three groups: Knowledge, Attitudes, and Behaviour.

Students Combined: Knowledge Questions

For the pre-test, the students indicated they knew least about: utilizing augmented reality to learn more about CC (X=2.523); the enhanced greenhouse effect (X=2.751); and how to create comic books about climate change (X=2.896). Each of these scored below the midpoint of the 5-point Likert scale. The highest score was for Knowledge Question (KQ) 7, "I know how to collaborate or work with other pupils to learn more about climate change" (X=3.718); this might reflect their overall experience in working with others rather than specific experience in working with others to learn about climate change. The results are summarized in Table 2.

For each Knowledge question, the post-test mean was greater than the pre-test mean, indicating that the students had benefitted from the CC lesson.

The Mean Percent Variation (M%V) provides the percentage by which the post-test mean differed from the pre-test mean (see Table 2). The greatest differences between the pre- and post-test were for KQ1, "I know the meaning of the enhanced greenhouse effect" (M%V =26.48%), and KQ4, "I know how to create comics about climate change" (M%V=25.380%). The smallest difference was for KQ7, "I know how to collaborate or work with other pupils to learn more about climate change" (M%V=6.583%), likely because this question scored the highest in the pre-test.

Table 2

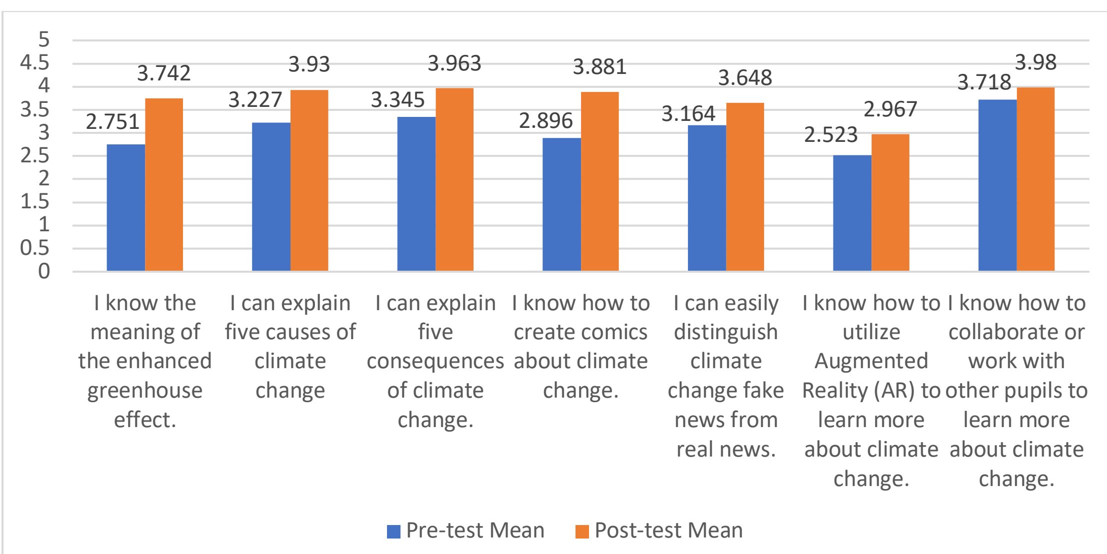
Students Combined: Pre-test and Post-test Results for Knowledge Questions (5-pt Likert Scale with 1=Strongly Disagree"

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V) (%)
Student Knowledge Q1	I know the meaning of the enhanced greenhouse effect.	2.751	3.742	26.483%
Student Knowledge Q2	I can explain five causes of climate change	3.227	3.930	17.888%
Student Knowledge Q3	I can explain five consequences of climate change.	3.345	3.963	15.594%
Student Knowledge Q4	I know how to create comics about climate change.	2.896	3.881	25.380%
Student Knowledge Q5	I can easily distinguish climate change fake news from real news.	3.164	3.648	13.268%
Student Knowledge Q6	I know how to utilize Augmented Reality (AR) to learn more about climate change.	2.523	2.967	14.965%
Student Knowledge Q7	I know how to collaborate or work with other pupils to learn more about climate change.	3.718	3.980	6.583%

Figure 1 demonstrates these results visually.

Figure 1

Students Combined: Pre-test and Post-test Results for Knowledge Questions



Students Combined: Attitude Questions

All the Attitude Questions (AQ) scored above the midpoint in the pre-test, with the highest score being for AQ1, "I believe climate change is real and dangerous" (X=3.934) (Table 3). The lowest mean was for AQ6, "I believe I am at great risk of being manipulated by climate change fake news" (X=3.030).

As with the Knowledge questions, **the mean response to the Attitude questions rose in every case between the pre-test and the post-test**, though some of the increases were small. The highest post-test score was for AQ1, "I believe climate change is real and dangerous" (X=4.270). The greatest difference between the pre- and post-test was for AQ2, "I believe I can have an impact on slowing climate change", with an M%V of 13.099%.

Table 3

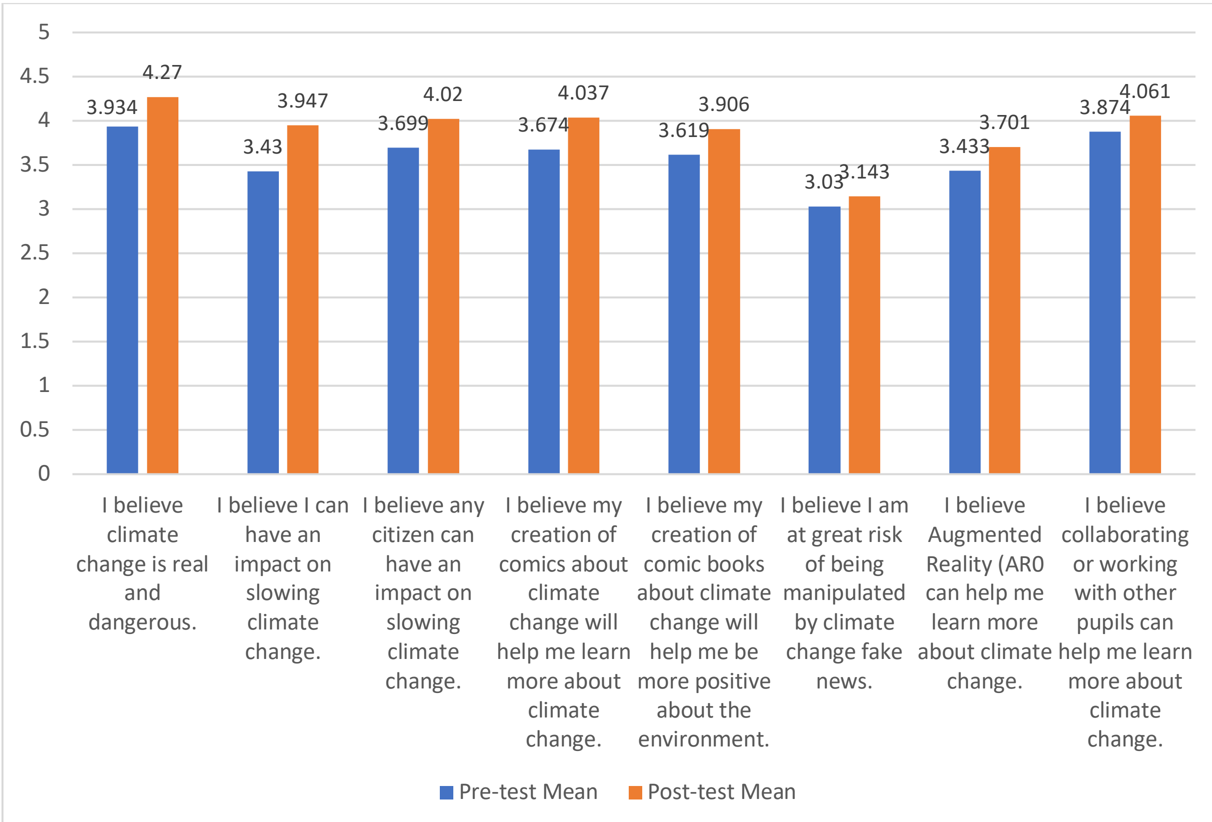
Students Combined: Pre-test and Post-test Results for Attitude Questions (5-pt Likert Scale with 1=Strongly Disagree"

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V)
Student Attitude Q1	I believe climate change is real and dangerous.	3.934	4.270	7.869%
Student Attitude Q2	I believe I can have an impact on slowing climate change.	3.430	3.947	13.099%
Student Attitude Q3	I believe any citizen can have an impact on slowing climate change.	3.699	4.020	7.985%
Student Attitude Q4	I believe my creation of comics about climate change will help me learn more about climate change.	3.674	4.037	8.992%
Student Attitude Q5	I believe my creation of comic books about climate change will help me be more positive about the environment.	3.619	3.906	7.348%
Student Attitude Q6	I believe I am at great risk of being manipulated by climate change fake news.	3.030	3.143	3.595%
Student Attitude Q7	I believe Augmented Reality (AR0 can help me learn more about climate change.	3.433	3.701	7.241%
Student Attitude Q8	I believe collaborating or working with other pupils can help me learn more about climate change.	3.874	4.061	4.605%

Results are also presented in Figure 2.

Figure 2

Students Combined: Pre-test and Post-test Results for Attitude Questions (5-pt Likert Scale with 1=Strongly Disagree"



Students Combined: Behaviour Questions

The last set of multiple choice questions focused on participant behaviours in order to examine whether the CC lessons translated into behavioral changes that might have a positive effect on the environment.

In general, the pre-test average for Behaviour Questions (BQ) was lower than that of the other categories. On the pre-test, the average of five of the eight Behaviour questions was below "3", the midpoint of the 1-5 Likert scale. The lowest initial score was for Behaviour Question 6 (BQ6), "I am actively using Augmented Reality (AR) to learn more about climate change", with a pre-test mean of 2.493 on a scale of 5. Still, this score is high considering it is unlikely any of the students were actually using AR in any context let alone to learn about CC. The highest pre-test average was for BQ1(X=3.156), "I am actively engaging in ways to combat climate change by reducing my carbon footprint". Still, this is only slightly above the Likert scale midpoint. The results are summarized in Table 4.

Table 4

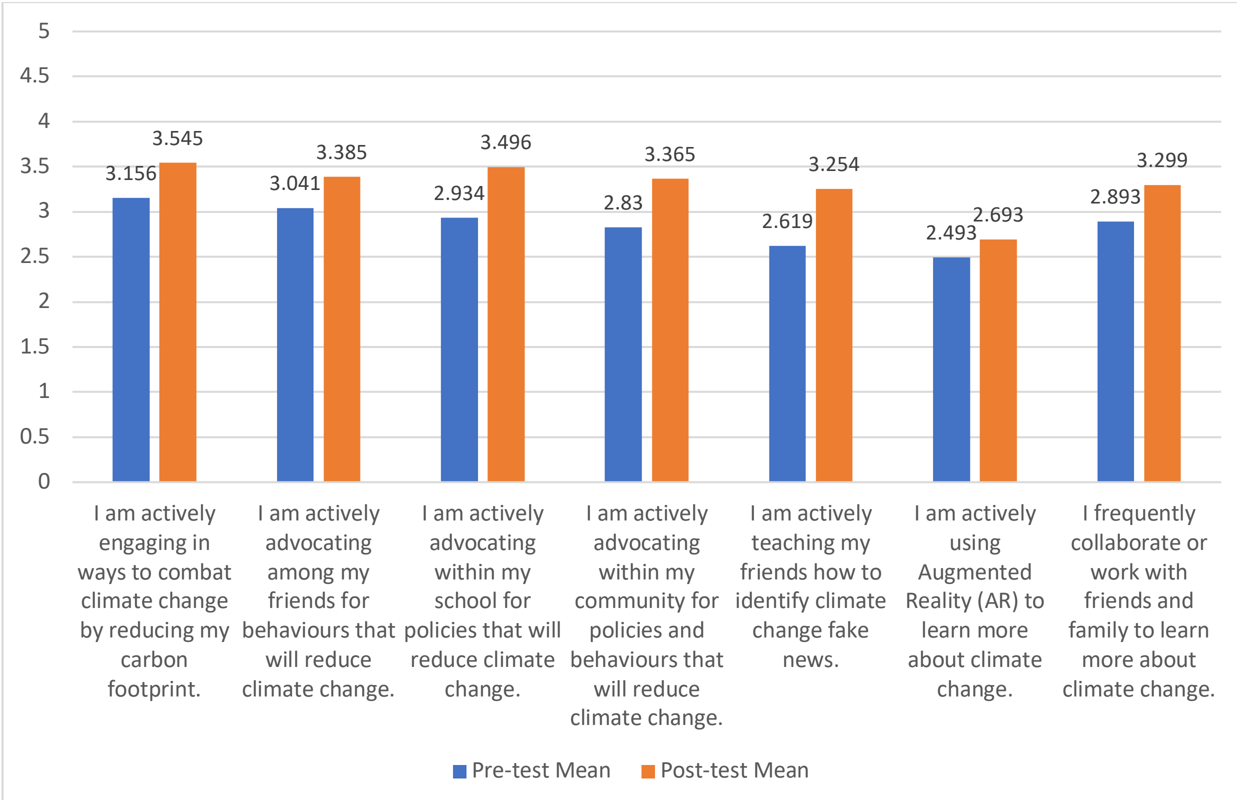
Students Combined: Pre-test and Post-test Results for Behaviour Questions (5-pt Likert Scale with 1=Strongly Disagree"

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V) (%)
Student Behaviour Q1	I am actively engaging in ways to combat climate change by reducing my carbon footprint.	3.156	3.545	10.973%
Student Behaviour Q2	I am actively advocating among my friends for behaviours that will reduce climate change.	3.041	3.385	10.162%
Student Behaviour Q3	I am actively advocating within my school for policies that will reduce climate change.	2.934	3.496	16.076%
Student Behaviour Q4	I am actively advocating within my community for policies and behaviours that will reduce climate change.	2.830	3.365	15.899%
Student Behaviour Q5	I am actively teaching my friends how to identify climate change fake news.	2.619	3.254	19.514%
Student Behaviour Q6	I am actively using Augmented Reality (AR) to learn more about climate change.	2.493	2.693	7.427%
Student Behaviour Q7	I frequently collaborate or work with friends and family to learn more about climate change.	2.893	3.299	12.307%

As with the Knowledge and Attitude questions, **in each case participants' scores on the Behaviour questions increased in the post-test**. In the post-test, the mean for BQ6, the lowest initial score, increased to 2.693, though this is still below the midpoint of the scale. The average for BQ1, "I am actively engaging in ways to combat climate change by reducing my carbon footprint" which had the highest mean of 3.156 on the pre-test, increased to 3.545 on the post-test. Overall, the biggest changes as measured by M%V were in response to BQ5, "I am actively teaching my friends how to identify climate change fake news" (19.514% increase) and BQ3, "I am actively advocating within my school for policies that will reduce climate change." (16.076% increase). The results are graphed in Figure 3.

Figure 3

Students Combined: Pre-test and Post-test Results for Behaviour Questions (5-pt Likert Scale with 1=Strongly Disagree"



Students Combined: Comparison of Survey Results by Category

Results of the Knowledge, Attitude, and Behaviour Questions can be compared by utilizing a Weighted Average (WAvg). This is calculated by summing up the mean value for each question in a specific category, and then dividing this sum by the number of questions in the category. This allows consideration of students' average response to each group of questions. The results are summarized in Table 5.

Table 5

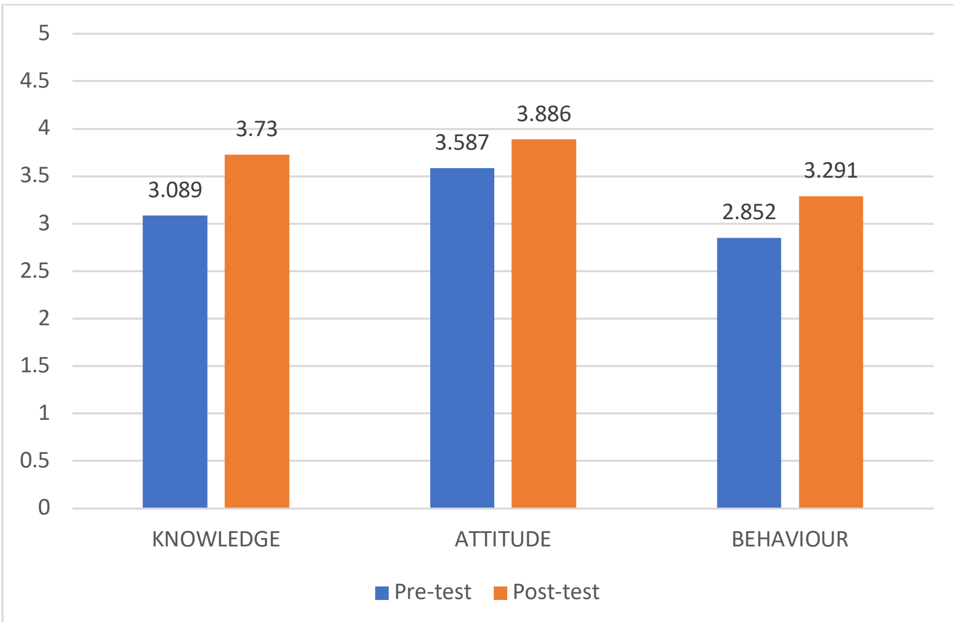
Students Combined: Weighted Averages of Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets

CC Latent Variable	Pre-Test WAvg	Post-Test WAvg	WAvg Variation (%)
KNOWLEDGE	3.089	3.730	17.185
ATTITUDE	3.587	3.886	7.694
BEHAVIOUR	2.852	3.291	13.339

For each category, the students' average increased between pre- and post-test. Overall, the greatest gain occurred in the Knowledge question set, with an increase of 17.185%. The smallest gain occurred in the Attitude question set, with an increase of 7.694%; note that this set had the highest initial average, which could explain a lower gain in the post-test. The results are graphed in Figure 4.

Figure 4

Weighted Averages of Student Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets



Student Results from Spain Analysed Separately

As exactly the same 57 students responded to the pre-test and post-test in Spain, the Spanish data is analysed on its own to perform tests of significance. As with the combined data, the analysis includes three sets of questions: Knowledge, Attitude, and Behaviour. As the Likert scale data is ordinal, the Wilcoxon signed rank test is used to test the difference between the pre-test and post-test means.

Students from Spain: Knowledge Questions

Table 6 presents data from the Spanish student pre- and post-test on the Knowledge questions, including tests of significance. **For each question, averages increased between pre- and post-test.** Three of the questions were highly significant ($p < .001$): KQ1, "I know the meaning of the greenhouse effect", KQ2, "I can explain five causes of climate change", and KQ4, "I know how to create comics about climate change". The remaining questions demonstrated an increase in knowledge in the post-test but were not statistically significant.

Table 6

Students from Spain: Pre-test and Post-test Results for Knowledge Questions (5-pt Likert Scale with 1=Strongly Disagree)

Survey Question	**Survey Question Text**	**Pre-test Mean (1-5)**	**Post-test Mean (1-5)**	**Mean % Variation (M%V) (%)**	**W**	**P-Value**
Student Knowledge Q1	I know the meaning of the enhanced greenhouse effect.	3.088	3.947	21.763	169.000	< **0.001**
Student Knowledge Q2	I can explain five causes of climate change	2.982	3.842	22.384	161.500	< **0.001**
Student Knowledge Q3	I can explain five consequences of climate change.	3.544	3.877	8.589	212.000	n.s. (0.079)
Student Knowledge Q4	I know how to create comics about climate change.	3.018	4.035	25.204	104.500	< **0.001**
Student Knowledge Q5	I can easily distinguish climate change fake news from real news.	3.632	3.789	4.144	391.500	n.s. (0.607)
Student Knowledge Q6	I know how to utilize Augmented Reality (AR) to learn more about climate change.	2.807	3.175	11.591	265.500	n.s. (0.193)
Student Knowledge Q7	I know how to collaborate or work with other pupils to learn more about climate change.	3.526	3.825	7.817	297.000	n.s. (0.182)

Students from Spain: Attitude Questions

Among the attitude questions, **in each case the results of the post-test demonstrated students were more engaged with climate change issues after the lesson** (Table 7). However, only one question was statistically significant, AQ2, "I believe I can have an impact on slowing climate change" (p=.037). It is interesting to note that in the pre-test, AQ2 "I believe I can have an impact…" scored 3.579 on the Likert scale, below AQ3, "I believe any citizen can have an impact…", which scored 3.842. However, in the post-test, AQ2 "I believe I can have an impact…" scored 4.000, above AQ3, "I believe any citizen can have an impact…" which scored 3.860. It appears that after the lesson the students felt more empowered and able to make an impact than they believed others were likely to.

Table 7

Students from Spain: Pre-test and Post-test Results for Attitude Questions (5-pt Likert Scale with 1=Strongly Disagree"

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V) (%)	W	P-Value
Student Attitude Q1	I believe climate change is real and dangerous.	4.018	4.228	4.967	183.00	n.s. 0.189
Student Attitude Q2	I believe I can have an impact on slowing climate change.	3.579	4.000	10.525	133.00	**0.037**
Student Attitude Q3	I believe any citizen can have an impact on slowing climate change.	3.842	3.860	0.466	228.50	n.s. 0.941
Student Attitude Q4	I believe my creation of comics about climate change will help me learn more about climate change.	3.719	3.860	3.653	259.00	n.s. 0.497
Student Attitude Q5	I believe my creation of comic books about climate change will help me be more positive about the environment.	3.544	3.842	7.756	299.00	n.s. 0.196
Student Attitude Q6	I believe I am at great risk of being manipulated by climate change fake news.	3.053	3.368	9.353	315.50	n.s. 0.199
Student Attitude Q7	I believe Augmented Reality (AR0 can help me learn more about climate change.	3.368	3.456	2.546	352.00	n.s. 0.789
Student Attitude Q8	I believe collaborating or working with other pupils can help me learn more about climate change.	3.754	3.895	3.620	181.50	n.s. 0.432

Students from Spain: Behaviour Questions

Table 8 summarizes results of the pre- and post-test behaviour questions administered to students in Spain. **In every case, self-report of behaviour related to managing climate change increased after the lesson**. Results were statistically significant for every question but BQ3, "I am actively advocating within my school for policies that will reduce climate change". This suggests students felt more empowered within their personal community than within their school.

Table 8

Students from Spain: Pre-test and Post-test Results for Behaviour Questions (5-pt Likert Scale with 1=Strongly Disagree"

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V) (%)	W	P-Value
Student Behaviour Q1	I am actively engaging in ways to combat climate change by reducing my carbon footprint.	3.018	3.614	16.491	185.50	**0.003**
Student Behaviour Q2	I am actively advocating among my friends for behaviours that will reduce climate change.	2.965	3.509	15.503	214.50	**0.012**
Student Behaviour Q3	I am actively advocating within my school for policies that will reduce climate change.	3.404	3.579	4.890	219.00	n.s. 0.397
Student Behaviour Q4	I am actively advocating within my community for policies and behaviours that will reduce climate change.	3.018	3.421	11.780	149.50	**0.029**
Student Behaviour Q5	I am actively teaching my friends how to identify climate change fake news.	2.333	3.263	28.501	98.00	**<.001**
Student Behaviour Q6	I am actively using Augmented Reality (AR) to learn more about climate change.	2.579	3.123	17.419	219.00	**0.044**
Student Behaviour Q7	I frequently collaborate or work with friends and family to learn more about climate change.	2.737	3.474	21.215	201.00	**0.003**

Students from Spain: Comparison of Survey Results by Category

As with the five countries combined, the results of Spain's Knowledge, Attitude, and Behaviour Questions can be compared. The results are summarized in Table 9, including Wilcoxon score and probability level.

Table 9

Students from Spain: Weighted Averages of Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets

CC Latent Variable	Pre-Test WAvg	Post-Test WAvg	WAvg Variation (%)	W	p
KNOWLEDGE	3.228	3.784	14.693	275.00	**<.001**
ATTITUDE	3.610	3.814	5.349	550.00	n.s. (0.291)
BEHAVIOUR	2.865	3.426	16.375	323.00	**<.001**

All categories demonstrate an increase between pre- and post-test. As the data from Spain includes perfectly matched pairs for pre- and post-test, it was also possible to utilize inferential statistics utilizing a paired samples test to calculate significance. The categories of Knowledge and Behaviour demonstrate significantly higher averages between pre- and post-test, while the difference in the Attitude category, the highest overall, is not significant.

Results – Teacher Survey

A pre-test and post-test survey were administered to the teachers from all five countries that were involved in the project. The survey questions in many cases were identical to those asked of the students, but some demographic and content questions directed to the teacher role. Forty teachers from five countries completed the pre-test survey. Twenty-two teachers completed the post-test survey (Table 10).

Table 10

Teachers completing the Pre-test and Post-test in Five Countries

Country	Pre-test n	Post-test n
Croatia	6	3
Greece	13	9
Malta	14	4
Portugal	4	3
Spain	3	3
Total	*40*	*22*

As with the combined students, the numbers completing the pre-test were not identical to those completing the post-test, and therefore inferential statistical analysis could not be used. Instead, the data from all teachers is combined, with all the Knowledge questions, all the Attitude questions, and all the Behaviour questions considered individually and in sets. An analysis of the Teacher open-ended questions is not included here, but this information is incorporated informally in the pilot teacher reports.

Teachers Combined: Knowledge Questions

In the pre-test the average of each question except for one was above the midpoint of the 5-point Likert scale. The average response to KQ6, "I can utilize Augmented Reality (AR) to facilitate climate change pupil learning" was 2.925, very slightly below the midpoint of 3. The highest score on the pre-test was KQ3, "I can explain five consequences of climate change" (X=4.275), followed closely by KQ2, "I can explain five causes of climate change" (X=4.200) (Table 11).

Table 11

Teachers Combined: Pre-test and Post-test Results for Knowledge Questions (5-pt Likert Scale with 1=Strongly Disagree"

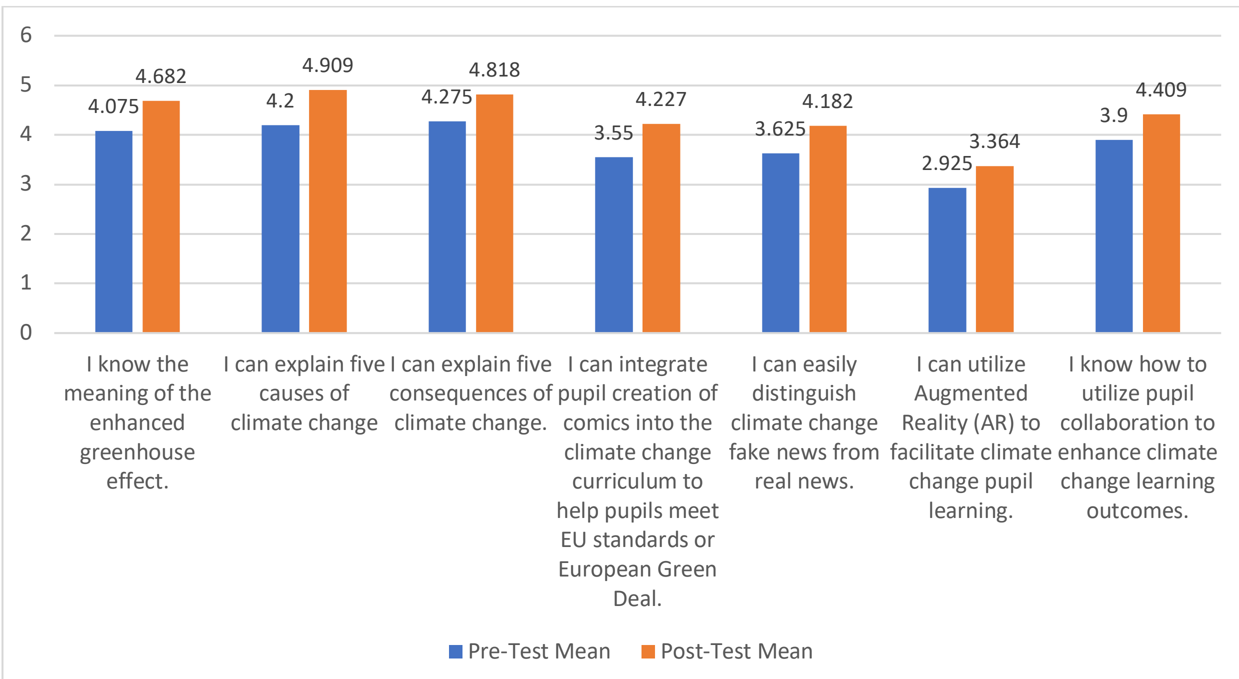
Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V) (%)
Teachers Knowledge Q1	I know the meaning of the enhanced greenhouse effect.	4.075	4.682	12.965%
Teachers Knowledge Q2	I can explain five causes of climate change	4.200	4.909	14.433%
Teachers Knowledge Q3	I can explain five consequences of climate change.	4.275	4.818	11.270%
Teachers Knowledge Q4	I can integrate pupil creation of comics into the climate change curriculum to help pupils meet EU standards or European Green Deal.	3.550	4.227	16.016%
Teachers Knowledge Q5	I can easily distinguish climate change fake news from real news.	3.625	4.182	13.319%
Teachers Knowledge Q6	I can utilize Augmented Reality (AR) to facilitate climate change pupil learning.	2.925	3.364	13.050%
Teachers Knowledge Q7	I know how to utilize pupil collaboration to enhance climate change learning outcomes.	3.900	4.409	11.545%

As with the students, **each knowledge question for the teachers demonstrated a gain between the pre- and post-test**. The largest gain was for KQ4, "I can integrate pupil creation of comics into the climate change curriculum to help pupils meet EU standards or European Green Deal" (16.016%), demonstrating the impact of training on implementation on this critical program (European Commission, 2019). The smallest gain was for KQ3, "I can explain five consequences of climate change" (X=4.818, M%V = 11.270%); recall that this was the highest scoring question in the pre-test and therefore there was not much room for improvement.

These results are depicted in graph form in Figure 5 below.

Figure 5

Teachers Combined: Pre-test and Post-test Results for Knowledge Questions



Teachers Combined: Attitude Questions

Every one of the Attitude questions that teachers responded to averaged above 4 on the Likert scale on both the pre-test and post-test. This is the only set of questions for which this occurred. The lowest score was AQ7, "I believe Augmented Reality (AR) can help me learn more about climate change" (X=4.000), while the highest score was AQ1, "I believe climate change is real and dangerous" (X=4.775). Results are summarized in Table 12.

Table 12

Teachers Combined: Pre-test and Post-test Results for Attitude Questions (5-pt Likert Scale with 1=Strongly Disagree"

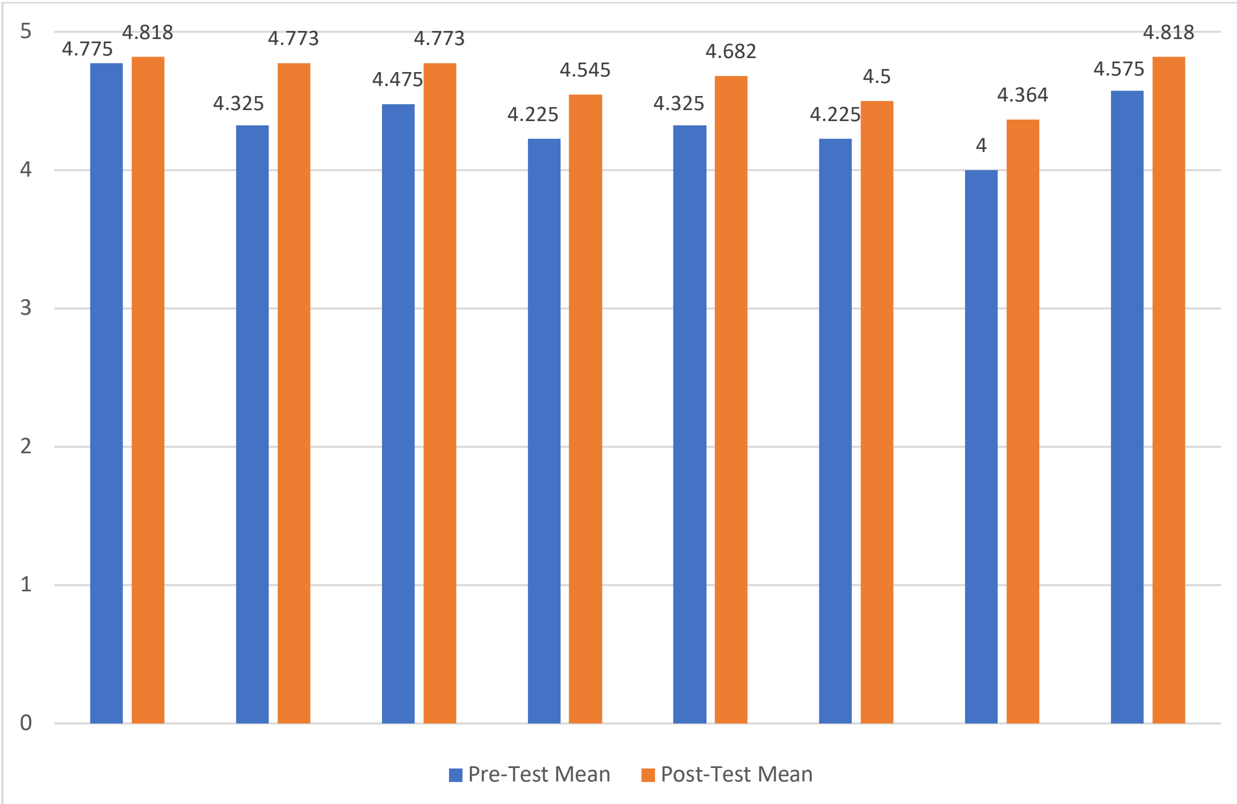
Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V)
Teacher Attitude Q1	I believe climate change is real and dangerous.	4.775	4.818	0.892%
Teacher Attitude Q2	I believe I can have an impact on slowing climate change.	4.325	4.773	9.386%
Teacher Attitude Q3	I believe any citizen can have an impact on slowing climate change.	4.475	4.773	6.243%
Teacher Attitude Q4	I believe my creation of comics about climate change will help me learn more about climate change.	4.225	4.545	7.041%
Teacher Attitude Q5	I believe my creation of comic books about climate change will help me be more positive about the environment.	4.325	4.682	7.625%
Teacher Attitude Q6	I believe I am at great risk of being manipulated by climate change fake news.	4.225	4.500	6.111%
Teacher Attitude Q7	I believe Augmented Reality (AR) can help me learn more about climate change.	4.000	4.364	8.341%
Teacher Attitude Q8	I believe collaborating or working with other pupils can help me learn more about climate change.	4.575	4.818	5.044%

Scores for teachers increased on every attitude question in the post-test. Mean % Variation for the Attitude Questions is lower than for the other sets of questions since the averages are so high to begin with. The lowest gain was for AQ1, "I believe climate change is real and dangerous" (X=4.818, M%V = 0.892%). The biggest gain was for AQ2, "I believe I can have an impact on slowing climate change" (X=4.773, M%V = 9.386%).

Results are graphed in Figure 6.

Figure 6

Teachers Combined: Pre-test and Post-test Results for Attitude Questions



Teachers Combined: Behaviour Questions

In the pre-test Behaviour question set, teacher responses ranged from an average of 2.675 for BQ6 ("I am actively using Augmented Reality (AR) to facilitate climate change pupil learning") to 4.150 for BQ2 ("I am actively advocating among my friends for behaviours that will reduce climate change"). Results are summarized in Table 13.

Average responses to each Behaviour question increased between pre- and post-test for the teachers. The highest score on the post-test was for BQ1, "I am actively engaging in ways to combat climate change by reducing my carbon footprint" (X=4.500). The next highest mean was 4.364, shared by BQ2 "I am actively advocating among my friends for behaviours that will reduce climate change" and BQ3 "I am actively advocating within my school for policies that will reduce climate change". The questions with the greatest gain were BQ5 "I am actively teaching my pupils how to identify climate change fake news" (M%V = 18.699%) and BQ7 "I frequently implement pupil collaboration to enhance climate change learning (M%V = 18.675%).

Table 13

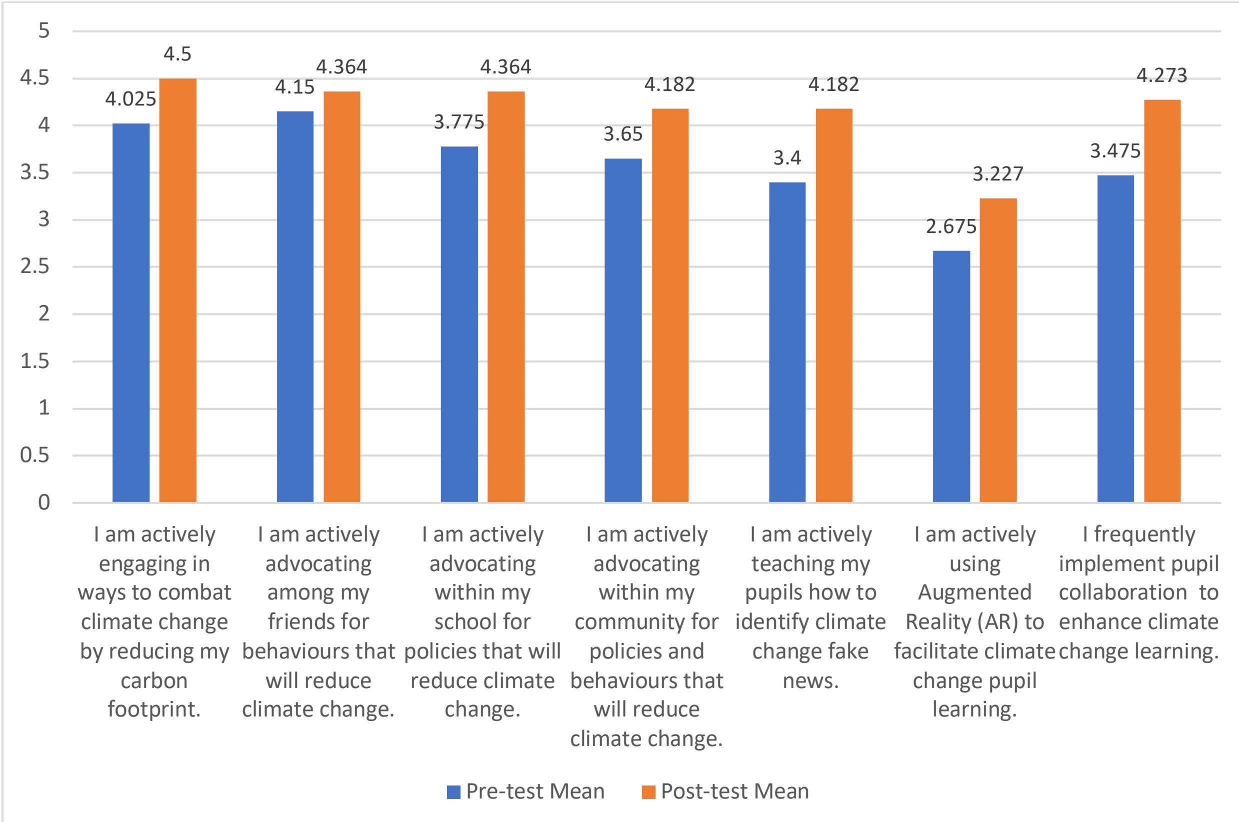
Teachers Combined: Pre-test and Post-test Results for Behaviour Questions (5-pt Likert Scale with 1=Strongly Disagree”

Survey Question	Survey Question Text	Pre-test Mean (1-5)	Post-test Mean (1-5)	Mean % Variation (M%V)
Teacher Behaviour Q1	I am actively engaging in ways to combat climate change by reducing my carbon footprint.	4.025	4.500	10.556%
Teacher Behaviour Q2	I am actively advocating among my friends for behaviours that will reduce climate change.	4.150	4.364	4.904%
Teacher Behaviour Q3	I am actively advocating within my school for policies that will reduce climate change.	3.775	4.364	13.497%
Teacher Behaviour Q4	I am actively advocating within my community for policies and behaviours that will reduce climate change.	3.650	4.182	12.721%
Teacher Behaviour Q5	I am actively teaching my pupils how to identify climate change fake news.	3.400	4.182	18.699%
Teacher Behaviour Q6	I am actively using Augmented Reality (AR) to facilitate climate change pupil learning.	2.675	3.227	17.106%
Teacher Behaviour Q7	I frequently implement pupil collaboration to enhance climate change learning.	3.475	4.273	18.675%

The results are graphed in Figure 7.

Figure 7

Teachers Combined: Pre-test and Post-test Results for Behaviour Questions



Teachers Combined: Comparison of Survey Results by Category

As with the Student data, the results of the Knowledge, Attitude, and Behaviour Questions are compared by utilizing a Weighted Average (WAvg), calculated by summing up the mean value for each question in a specific category, and then dividing this sum by the number of questions in the category. This allows consideration of teachers' average response to each group of questions. The results are summarized in Table 14.

Table 14

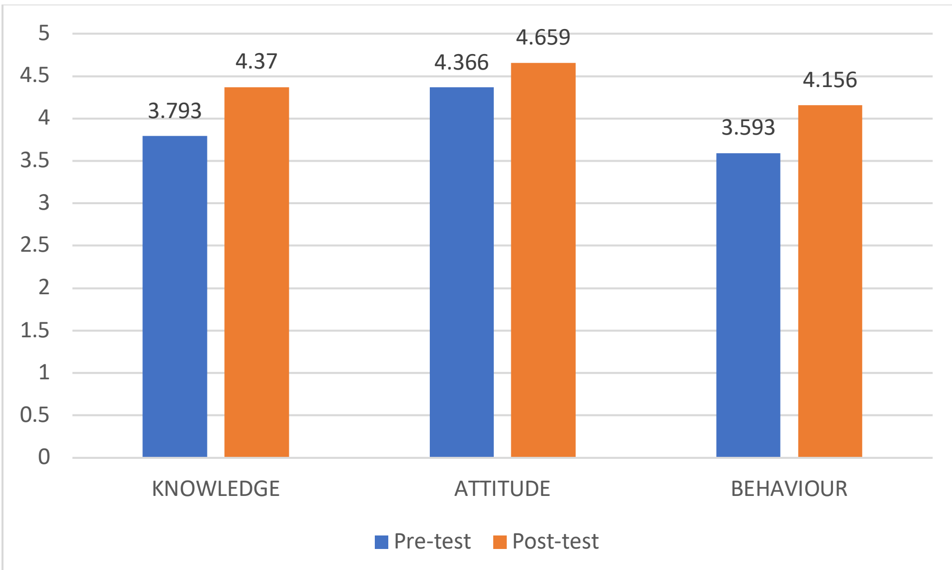
Teachers Combined: Weighted Averages of Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets

CC Latent Variable	Pre-Test WAvg	Post-Test WAvg	WAvg Variation (%)
KNOWLEDGE	3.793	4.370	13.204%
ATTITUDE	4.366	4.659	6.289%
BEHAVIOUR	3.593	4.156	13.547%

For each category, the teachers' average increased between pre- and post-test. Overall, the greatest gain occurred in the Behaviour question set, with an increase of 13.547%, followed closely by the Knowledge question set, with an increase of 13.204%. The smallest gain occurred in the Attitude question set, with an increase of 6.289%. Note however that, as with the student data, the Attitude set had the highest initial average, which could explain why the gain was lowest for this set in the post-test. The results are graphed in Figure 8.

Figure 8

Weighted Averages of Teacher Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets



Result Comparison – Student and Teacher Question Sets

In most cases, questions in the Student and Teacher question sets were identical, but in several cases, they differed as to perspective. For example, students were asked about their own use of tools to learn about CC while teachers were asked about utilizing tools to teach CC to students. As a result, rather than directly comparing each question, this analysis will directly compare the questions sets: Knowledge, Attitude, and Behaviour.

Table 15

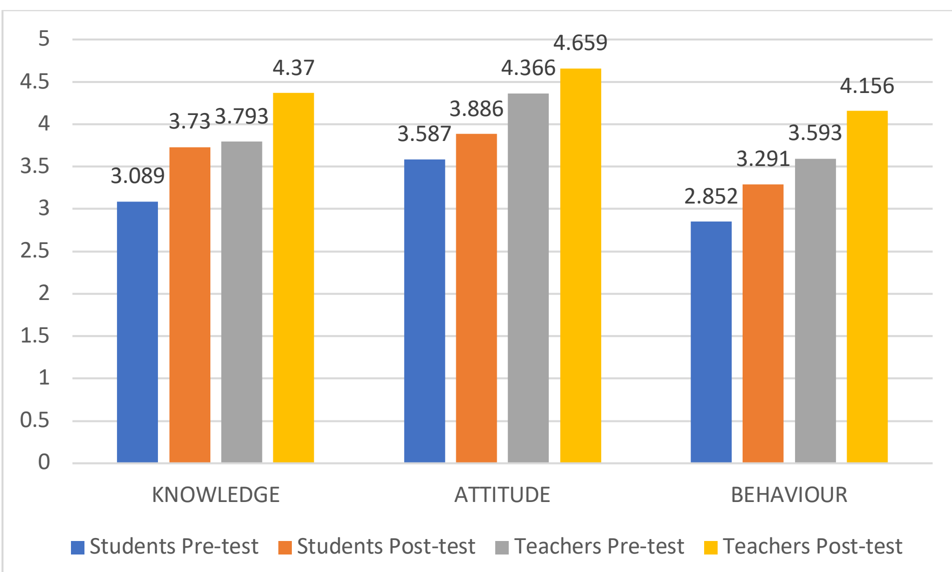
Comparison of Students and Teachers: Weighted Averages of Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets

Question Set	Students		Teachers	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
KNOWLEDGE	3.089	3.730	3.793	4.370
ATTITUDE	3.587	3.886	4.366	4.659
BEHAVIOUR	2.852	3.291	3.593	4.156

These results summarize the effectiveness of the lessons for both the Student and Teacher groups. For each group, on each question set, the average of the post-test exceeded that of the pre-test. It is also possible to see that for each question set, while the average of the Student post-test increased from that of the pre-test, it still fell below the average of the Teacher pre-test. For example, for the Knowledge question set, the Student post-test average was 3.730, while the Teacher pre-test average was 3.793, rising to 4.37 on the post-test. Results are graphed in Figure 9.

Figure 9

Comparison of Students and Teachers: Weighted Averages of Pre- and Post-test Knowledge, Attitude, and Behaviour Question Sets



Conclusions

For both Students and Teacher groups, for each Knowledge, Attitude, and Behaviour question and for each question set, there was an increase in desired response between the pre-test and post-test. This suggests that **the teacher training and student lessons were effective in increasing student knowledge, attitudes, and behaviour with respect to climate change.**

Logistical challenges during the pilot suggest simplifying some procedures for large scale implementation. It will not be necessary, for example, to require administration of a pre-test since the results of the pilot are sufficient to demonstrate the effect of the treatment.

References

Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). *GreenComp The European sustainability competence framework* (No. JRC128040). Joint Research Centre (Seville site).

Bryan, J., & Henry, L. (2012). A model for building school–family–community partnerships: Principles and process. *Journal of Counseling & development*, *90*(4), 408-420.

European Commission. (2019). *The European Green Deal*. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

European Commission (EC). (2020). *Digital Education Action Plan (2021-2027)*. https://education.ec.europa.eu/focus-topics/digital-education/action-plan

European Commission (EC). (2021, July 4). *Eurobarometer survey: Europeans consider climate change to be the most serious problem facing the world*. https://ec.europa.eu/commission/presscorner/detail/en/ip_21_3156

European Commission. (2024, May). Attitudes of Europeans towards the environment. https://Europa.eu/eurobarometer/surveys/detail/3173

European Council (2022, June 16). Council adopts recommendation to stimulate learning for the green transition and sustainable development. https://consilium.europa.eu/en/press/press-releases/2022/06/16/council-adopts-recommendation-to-stimulate-learning-for-the-green-transition

Goller, A., & Rieckmann, M. (2022). What do we know about teacher educators' perceptions of education for sustainable development? A systematic literature review. *Journal of Teacher Education for Sustainability*, *24*(1), 19-34.

Nidhom, A. M., Smaragdina, A. A., Dyah, K. G., Andika, B. N. R., Setiadi, C. P., & Yunos, J. M. (2019, October). Markerless Augmented Reality (MAR) through Learning Comics to Improve Student Metacognitive Ability. In *2019 International Conference on Electrical, Electronics and Information Engineering (ICEEIE)* (Vol. 6, pp. 201-205). IEEE.

Rosado-García, M. J., Kubus, R., Argüelles-Bustillo, R., & García-García, M. J. (2021). A new European Bauhaus for a culture of transversality and sustainability. *Sustainability*, *13*(21), 11844.

Tatalovic, M. (2009). Science comics as tools for science education and communication: a brief, exploratory study. *Journal of science communication*, *8*(4), A02.

Acknowledgements

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.

We would like to thank the Léargas Irish National Agency for its continuous support.

Author Details

Orestes Varonis
PARAGON-eduTech
Greece
Varonis.orestes@gmail.com

Evangeline (Litsa) Varonis
PARAGON-eduTech
Greece
Lvaronis@gmail.com

George Sarrigeorgiou
PARAGON-eduTech
Greece
Gsarrigeorgiou@gmail.com

Anastasia Pyrini
CleverBooks
Ireland
nancypyrini@icicte.org

Darya Yegorina
CleverBooks
Ireland
dasha.jegorina@gmail.com

SUSTAINABILITY IN MEDIA EDUCATION: COLLABORATIVE STRATEGIES FOR CURRICULUM DEVELOPMENT AND PROFESSIONAL EMPOWERMENT BY THE SUMED PROJECT

Ġorġ Mallia and Monika Maslowska
University of Malta
MALTA

Abstract

Sustainability has become a very important aspect both in education and in industry. The United Nations' Agenda 2030 has 17 sustainable development goals (SDGs) that need to be implemented. An EU co-funded project called SUMED, linking together five institutions from four countries, is working with University level media contents, as well as with the media industry, both to analyse the situation regarding the integration of sustainability goals within the curricula of the first and the working model of the second, and creating new or redesigned curricula that implement SDGs in media courses, leading to a more skilled and richer knowledge base for students that can then be trasferred to industry. This paper looks at sustainability at University level and at the place of work and also reports on four different approaches taken by SUMED partners in order to fulfill the aims of the project.

Introduction

Despite the dynamic nature of media formats, tools, and methods, professionals in the field often overlook sustainability. Professionals include teachers of media in the higher institutions, as well as media practicioners working in the industry.
The EU co-funded project SUMED (*Sustainable Multidimensional Media Contents*) was initiated by institutions in four countries, with the intention of recognizing the pressing societal and environmental calls for sustainability, alongside concerns for health and well-being in the workplace. The aim of the partner institutions is to transform media education to encourage a more structured inclusion of the professional uncertainty for sustainability dimension in the training of education professionals.

The SUMED project partners are INNOCAMP.PL and the University of Gdańsk, both from Poland, the Universidad Politècnica de València in Spain, the Turku University of Applied Sciences in Finland, and the University of Malta in Malta.

The paper argues that sustainability must permeate the entire media supply chain, emphasizing the need to integrate sustainability criteria into the education of future media professionals.

Each SUMED partner has conducted training sessions for media teachers who designed or redesigned their courses and curricula for students to accommodate evolving needs. The development of re-structured curricula and courses is envisioned to not only benefit local communities and organizations but also to empower new employees with relevant skills.

Sustainability in Media: A Review of the Literature

"Sustainability can be broadly understood as the ongoing viability of the complex interconnection between the environment and human activ- ity. Sustainability is fundamentally concerned with the nurturing of the health and productive capacity of the environment and all its constituent elements—land and soil, water, air, biodiversity, vegetation, and animal welfare." (Craig, 2019, p.3)

Attempting to solve major unsustainable problems, the United Nations prepared its Agenda 2030, which has 17 sustainable development goals (SDGs) (United Nations, 2015). It was always intended that higher education institutions be among the first to implement these goals, helping to ascertain the practical usage and awareness of these goals, and most of these institutions worldwide took on the task in an official way. On the global stage, the Johannesburg Earth Summit of 2002 endorsed the proposal that sustainable development must be an integral component of all levels of education: "Sustainability appears to be our best hope for solving an ecological crisis that resulted from the material processes, outcomes, and mindset associated with modern technology." (Bendor, 2018, pp. 1-2)

Indications on progress show that "major progress has been made in actions related to the environmental management of their campuses, or the creation of green structures. However, a sustainable university must be committed to sustainability in more than campus greening programs and must include proper education and training, involve new ways of doing research, and promote an authentic engagement with the community" (Collazo Expósito & Grandos Sánchez, 2020).

This echoes what was written by Albareda-Tiana, et al., (2018), when they said that with regards to the implementation of the SDGs "Transformation is a complex and long-term ambition. It must start by recognizing the SD agenda calls for a paradigm shift in education. It is not only a matter of transforming institutional responsibility but also curriculum reorientation and teaching to better serve the needs of current and future generations." (p. 474).

The need for sustainability training has been recognized for some time. But it is extremely difficult to implement, primarily because of the lack of know-how in its regard. “Currently, industry, community and university groups have limited knowledge of how tertiary educators understand and use the ideas of sustainability within their teaching programs” (Reid & Petocz, 2006). In fact, Reid and Petocz found that the majority of the participants of their research saw sustainability and teaching as separate entities. The authors had expected a higher degree of awareness of issues of sustainability and a greater integration into teaching programmes. Indeed “for many scholars, effective implementation of sustainability commitments implies the integration of sustainability across the curriculum” (Green, 2013, p. 135).

A multi-country study, aimed at identifying the level of importance given to competences on sustainable development by teaching staff at a number of higher education institutions, found that there were “competences needed for teaching about sustainable development that center around learning to know, learning to do, learning to be and learning to live together in relation to knowledge of sustainability problems, interdisciplinary and analytical thinking, developing solutions, and recognizing diverse values.” (Leal Filho, et al., 2021, pp. 110-111). An overall suggestion coming from this study, which took place in 40 countries, was that sustainability teaching competence building could be made stronger if prominently placed as one of the learning objectives in graduate courses and degree programmes.

A study that compares the strategic implimentation of sustainability practices in four English and four Australian universities (Ralph & Stubbs, 2014), found that what is needed is “clear leadership in a number of areas: prioritising interdisciplinary collaboration; providing resources to undertake the work required; and providing the university community with the necessary information, skills and knowledge. The importance of engaging, informing and resourcing university staff of the university is critical to the success of integrating environmental sustainability into all areas” (p.87).

In fact, this across-the-board method seems to be the favoured one by all researchers in this area. “To strengthen education as a substantive function, curricula must be updated and integrated into the context of education for sustainability in its environmental, social and economic dimensions. Thus, one of the main challenges for the university is to rethink the curriculum, which in this process requires the participation of managers, teachers, students and the entire university community.” (Brito et al., 2018, p. 14)

The difficulties are real. A content analysis of over a thousand bachelor and masters degree programmes and their related curricula in 28 European countries showed that the level of curricular integration of sustainability aspects in the field of media and communication is low (14%) to very low (6%) on module level (Karmasin & Voci, 2021). The authors admit that the journey in this direction will be a long one.

Beyond the university, and potentially utilising a workforce trained in sustainability by Universities, industry too needs to integrate sustainability-related initiatives. Social media is often used as vehicles of communication between industry and its stakeholders. However, "sustainability-related communication by large corporations and its impact on consumers remains an understudied area" (Jha & Verma, 2023, p. 723). Hence the SUMED project's emphasis on this aspect, also taking on board Corporate Social Responsibility as a way of ascertaining the sustainability of practice (Weder et al., 2023).

Very little research, for example, exists on how the audio-visual sector can be sustainable, environmentally, socio-culturally and economically. *Green Shooting* has become a term that describes sustainability in all the different stages of audio-visual production (Lopera-Mármol & Jiménez-Morales, 2021). Again, here, universities need to play a role, preparing for an industry that needs the expertise to incorporate sustainability practices: "there is a lack of academic involvement, if the audio-visual sector and academia amalgamation could lead to more cohesive industry development in sustainability standards" (p.12).

The examples from research taken on by SUMED partners follow on from the literature above.

Research Carried out by SUMED Partners

A number of the partners in the SUMED project have been running research and experimental work in order to determine the extent and feasability of sustainable goals being met by media teachers, media students and the media industry. Below are four examples of this work, which has led to a better understanding of the collaborative strategies needed or in place for a sustainability curriculum[2]. All are based on papers published in two booklets by the SUMED project.

Industry Interviews

Halonen et al. (2024) report on three person-to-person structured interviews were conducted with emloyees of three Finnish companies operating in different sectors of media: namely, the Finnish Public Service media company, Yle, a private marketing company, and a private film production company. The main topics of

[2] Based on EMAS https://green-business.ec.europa.eu/eco-management-and-audit-scheme-emas_en

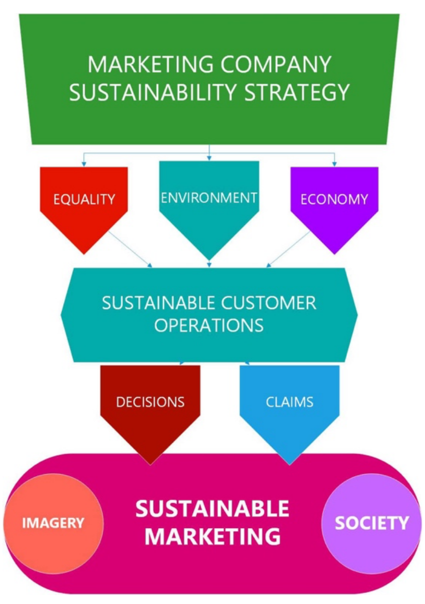
the interviews were sustainability and responsibility issues. An analysis was also made of the companies' own regulations and guidelines considering sustainability. Asking about how sustainable was the day to day work in each of the companies, it was clear that the terms by which sustainability could be practiced were not too clear. The interviewee in Yle, for example, admitted that the actual terms are not being talked about. However, that did not mean that sustainability was not part of the structure. He said that, in fact, it was already well organised. The training offered by Yle ascertained that journalistic guidelines and Yle's own guidelines, rules, and values were adhered to.

This was mirrored by what the employee of the private film production company said. The interviewee insisted that sustainability issues have been under scrutiny in the company for circa five years, with the company continally seeking material with sustainable relevance for its storylines, and with a sustainability strategy actively engaged. The Me-Too movement had triggered a need for social responsibility, with open discussion about everything related to its ramifications.

The interviewee of the marketing company was found to be passionate about sustainability and responsibility, making particular efforts to incorporate these values into everyday work. This referred particularly to environmental responsibility, social responsibility, and economic responsibility, dealing with equality, the environment, and the economy (Figure 1). The context is the sustainability strategy of the individual company and then the forces at play are depicted to lead to sustainable marketing

Figure 1

*Visual Representation of Sustainable Values in Marketing Decision Making (*Graphic by: Pentti Halonen)

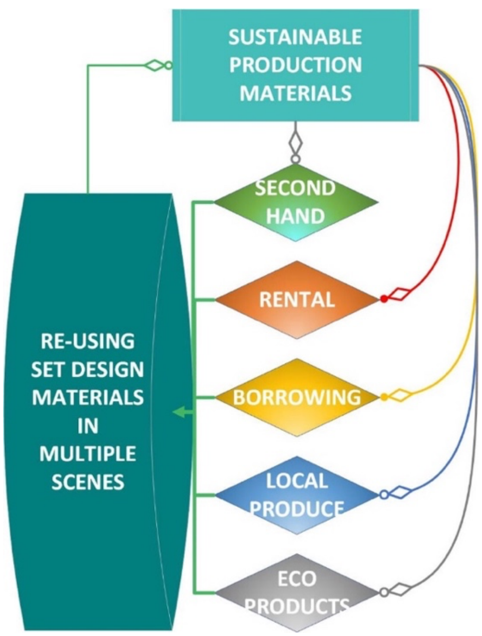


These responsibilities translate into practical terms: for example, when new campaign products are being designed: in the choosing of printing inks and in the design of new packaging. The less colour needed, the more environment-friendly the packaging is. Environmental issues are also being addressed by choosing trains for travel to meetings and opting for snacks during coffee breaks from local companies – the company's aim is to prefer the local businesses.

Renewability of materials is also at the forefront of considerations (Figure 2). The employees themselves have been given the opportunity to take part in writing the guidelines on responsibility.

Figure 2

A Visual Representation of How Production Materials Can Be Sustainable in the Media Industry. (Different ways of doing this are presented; Graphic by: Pentti Halonen)



Though the interviews are in no way representative, they are indicative of the fact that steps towards a more sustainable media work can be and are already being taken by the industry, not only by the employees themselves, but by the company's directors who "ensure that every employee is not only aware of the principles but also takes them into account in daily work." (Halonen, Kuusela & Järvipetäjä (2024), p. 52.

Green Screenwriting

Maslowska (2024) reports on the outcomes of three undergraduate screenwriting projects from the University of Malta. The students created screenwriting portfolios under the overarching theme of "Green Filmmaking: Screenwriting for Today's Climate." The primary focus was on how sustainability principles were incorporated into these creative projects. This was followed by an analysis of the students' decision-making processes and an assessment of how sustainability concepts were integrated into their screenplays.

The project brief for the 2020-2023 cohort focused on "planet placement", encouraging students to write screenplays that promoted sustainable behaviours. The brief emphasized the use of local settings, minimizing resource consumption, and fostering a mindset where sustainability becomes an integral part of the creative process rather than an afterthought. In other words, the challenge was to create environmentally friendly screenplays where sustainable practices were an integral part of the story itself, without explicitly focusing on ecological issues.

Out of 25 projects, three screenplays were randomly selected. Each screenplay was assessed in terms of the students' approach to the theme, narrative elements, genre classification, storyline development, impact on sustainability, and how these elements contributed to the overall effectiveness and message of the work.

As hoped, it was evident that sustainable principles were deeply ingrained within their approach to screenwriting.

Student A:

Approach: Opted for a singular primary setting, an apartment complex, to minimize resource usage and production expenses.

Narrative Elements: Integrated sustainable practices such as bicycling, recycling, and reusable water bottles into the "coming-of-age" storyline.

Genre Classification: Coming-of-age

Storyline Development: Followed a protagonist navigating daily challenges, subtly revealing sustainable behaviours as part of their routine.

Impact: Illustrated how individual actions, even in mundane situations, contribute to a broader environmental initiative, fostering relatability and achievable sustainability goals.

Student B:

Approach: Chose a singular primary setting, Malta, to highlight environmental challenges and minimize production costs.

Narrative Elements: Seamlessly intertwined environmental activism with personal anecdotes, addressing wider socio-environmental concerns.

Genre Classification: Dramedy

Storyline Development: Centred around a character inspired by real-life events, aiming to engage viewers with familiar settings and pertinent environmental issues.

Impact: Emphasized the significance of community engagement and individual accountability in tackling environmental challenges, advocating for collective action.

Student C:

Approach: Positioned the narrative in an unspecified future, exploring the aftermath of an environmental catastrophe to convey a sense of urgency.

Narrative Elements: Featured two child protagonists to underscore innocence and vulnerability amidst ecological crises.

Genre Classification: Sci-fi

Storyline Development: Illustrated the resilience and adaptability of children amidst environmental adversity, conveying a message of hope and urgency.

Impact: Aimed to resonate with audiences by evoking empathy for future generations and prompting immediate action to address pressing environmental concerns.

The screenplays suggest that the students understood eco-screenwriting tropes implementing critical and creative application of sustainability principles into screenwriting. The diverse methods employed by the students reveal a blend of personal experiences and research, resulting in narratives that not only entertain but also raise awareness about critical environmental issues. Moreover, the emphasis on sustainability in these screenwriting projects reflected a broader trend in the media industry, where environmental responsibility is becoming increasingly important. By cherishing these values in our students, the aim is to support their development as environmentally conscious storytellers who can inspire positive change through their narratives and contribute to a more sustainable future in the media landscape and beyond.

Sustainable Journalism Education

Anikowski and Jagiełło Rusiłowski (2024) propose an educational metaphor they call “the Beehive” (Figure 3), exploring its historical roots and contemporary application in adopting sustainable learning systems within communities of practice. Originating from practices at Oxford University in the 1940s, influenced by Professor Rege Revans’ approach to Action and Inquiry-based Learning, the

Beehive concept emphasizes collaborative problem-solving and collective intelligence (Revans, 1982).

Drawing from Lev Vygotsky's socio-cultural theory (Vygotsky, 1978), it highlights the importance of providing students with mediating tools to facilitate communication and understanding within both individual and collective contexts.

Figure 3

A Visual Representation of the Beehave Model for Sustainable Learning Systems, including All the Elements Needed for Sustainability. (Graphic by: Oliwia Woźnicka)

The report suggests that the Beehive approach offers a unique framework for diffusing innovation and managing tensions related to change. By promoting a sense of belonging and empathy, it aims to disarm resistance and create conducive environments for learning and change-making. This approach reflects Vygotsky's zone of proximal development (1978), emphasizing the importance of scaffolded learning experiences within supportive environments. Furthermore, the report explores the metaphorical implications of the Beehive in educational and design contexts, emphasizing the value of cognitive, social, and cultural exchanges in generating sustainable solutions. It underscores the importance of cross-pollination of expertise and talents in fostering creativity and effective communication.

Anikowski and Jagiello Rusiłowski (2024) also discuss participatory communication methods as integral to improving communication within the beehive framework. Drawing from anthropology and social psychology, as well as active listening techniques, these methods aim to foster trust, conscious participation, mutual respect, and engagement within diverse communities.

Active listening involves being active, open to dialogue, and questioning one's certainties.

Sclavi (2014) formulated seven rules for active listening:

1. Take time to conclude.
2. Change perspective to see different viewpoints.
3. Assume others are right and seek to understand how and why.
4. Emotions convey information about how one sees, rather than what is seen.
5. A good listener explores various perspectives.
6. Embrace paradoxes and disagreements as opportunities for creative conflict management.
7. Humour can be a tool for mastering the art of listening.

Highlighting a practical application of the Beehive concept, Anikowski's and Rusilowski's (2024) report describes the "Media for Climate" event organized by INNOCAMP.PL in December 2023. Bringing together media professionals, educators, activists, and government officials, the event aimed to explore sustainable communication approaches in journalism education. Through trust-building activities, screenings, and discussions, participants exchanged insights and experiences, emphasizing the importance of positive, solution-oriented communication in addressing environmental challenges.

Anikowski and Jagiello-Rusiłowski (2024) conclude with recommendations for sustainable journalism education, emphasizing the need for institutional change, positive communication practices, and innovative teaching methods. The conclusion highlights the importance of engaging diverse perspectives and fostering critical thinking skills among future journalists to communicate sustainability issues effectively. The participants' recommendations were as follows:

- Sustainable journalism education cannot happen without institutional change in higher education. Academia needs to be oriented towards sustainability issues and methods that allow for more flexibility and multidirectional communication. Providing good examples is the best way to gradually influence institutional change.
- Journalists should be trained to use positive, solution-oriented communication, which empowers those receiving media content, engages them in social initiatives, and prevents news avoidance.
- Young journalism students can be reached more easily and effectively through digital channels. Not only are they there every day, but it is much

less stressful for them, because they are not stigmatized, so this is an appropriate way to engage them in sustainability.

- Tools and methods for training future journalists should take the form of fact-checking tools, methods to expose greenwashing, and any additional ways to strengthen critical thinking. Young journalists should also meet with people from different backgrounds: science, media, and culture, to get their perspectives and knowledge, leaving comfort zones, but trying to reach people from other communities to build sustainability, which is fruitful for their future work and for understanding the complex nature of sustainability. (Anikowski & Jagiello-Rusiłowski, 2024, p.65)

Raising Sustainability Awareness through Communication

The Universitat Politècnica de València implemented a number of research activities with teachers, seeking to understand the important role that communication plays in addressing the challenges facing the planet. In his report on these activities, Julio González Liendo (2024), refers to a survey carried out by Professor Nuria Lloret Romero from the same university, with 50 communication teachers at three campuses of the University.

Quoting directly from the report:

- the teachers attest that communication plays a pivotal role in sustainability by fostering organisational transparency (38%), aiding understanding of the planet's evolving reality (38%) and emphasising the significance of sustainability training for communication teachers helps with understanding the importance of media in societal transformation (16%).
- When asked to evaluate the importance of sustainability training for communication teachers, 18% rated it as the highest priority, 9% assigned it a score 9 out of 10, 27% ranked it in the eighth place, 9% rated it as a 7, and 18% rated it as a 6.
- When asked, "To what extent can sustainability training for communication teachers help them understand it?" 27% believe that it facilitates comprehension of various educational dynamics for transferring sustainability concepts and their professional implications to communication students. Another 27% argue that it assists in defining specific sustainability content and methods for its integration into subjects and communication. Additionally, 18% think that such training aids in understanding the diverse dimensions of sustainability.
- The teachers who participated in the survey revealed that undergoing training through courses and workshops on sustainability greatly enhanced their teaching abilities, enabling them to incorporate effectively this content into their study units (45%). Additionally, 18% acknowledged that such

> training would deepen their understanding of the true scope of the Sustainable Development Goals (SDGs), while 9% emphasized its role in elucidating the significance of communication within sustainability processes. Furthermore, it was noted by 9% of respondents that such training assists in addressing didactic shortcomings, facilitating knowledge transfer, and fostering a shift in perception regarding sustainability and its ramifications. (González Liendo, 2024, p. 53)

It was suggested by other research carried out by the university that promoting messages and practices that drive positive change towards sustainability, establishing strategies to reduce climate anxiety, fostering Earth coalitions, countering long-term stress, and seeking meaning at work would be fruitful. The importance of promoting critical thinking and fact-checking as essential tools for journalism students, reflecting the research of Anikowsi and Jagiello Rusiłowski, was also emphasised by the participants of the research.

There is definitely a need for a continuous discussion about the challenges faced by communication professionals in implementing sustainable practices in a digitalized world.

Conclusion

The multi-pronged approach taken on by the SUMED partners in research on sustainability practices is intended to both understand what practices are actually already in place, and also how new models of curriculum development can help add to those practices, both at teaching and learning levels, as well as at an industry level.

This can be clearly seen in the reinvention of screenwriting to go the green way in the Maslowska (2024) experiment, as well as in Anikowski and Jagiello-Rusiłowski's 2024 Beehive model, infusing teaching with much needed sustainable practices, particularly in the light of the negatives indicated in the Gonzalez Liendo (2024) report regarding perception of sustainability goals by academics.

The successful transitioning from school desk to industry in the audio-visual sector, as reported by Halonen et al., is therefore a breath of fresh air, and a clear indication how curricular redesigning to embrace sustainability practices can leave a clear and fruitful result.

References

Albareda-Tiana, S., Vidal-Raméntol, S., and Fernández-Morilla, M. (2018). Implementing the sustainable development goals at University level. *International Journal of Sustainability in Higher Education 19*(3): 473-497. https://doi.org/10.1108/IJSHE-05-2017-0069

Anikowski, A., & Jagiello-Rusilowski, A. (2024). “The Beehive”: A proposal for designing sustainable media interventions. In M. Maslowska & Ġ. Mallia (Eds.), ,*Cases of sustainable media: Sustainable multidimensional media contents (SUMED), Booklet 2, pp. 56-66.* SUMED. https://sumed-project.eu/assets/sumed-booklet2.pdf

Bendor, R. (2018). *Interactive media for sustainability.* Cham, Switzerland: Palgrave Macmillan.

Brito, R. M., Rodríguez, C., & Aparicio, J. L. (2018). Sustainability in teaching: An evaluation of university teachers and students. *Sustainability 10*(2), 439. https://doi.org/10.3390/su10020439

Collazo Expósito, L. M., and Granados Sánchez, J. (2020). Implementation of SDGs in University Teaching: A Course for Professional Development of Teachers in Education for Sustainability for a Transformative Action. *Sustainability 2020*, *12*(19*)*, 8267, 1-19. https://doi.org/10.3390/su12198267

Craig, G. (2019). *Media, sustainability and everyday life.* London: Palgrave Macmillan. DOI:10.1007/978-3-319-70383-1

European Union. (2024). *Sustainable multidimensional media contents*. https://sumed-project.eu/

Gonzalez Liendo, J. (2024). Development of skills and didactics to raise awareness about the importance of sustainability in the new generations of communicators. In M. Maslowska & Ġ. Mallia (Eds.), *Cases of sustainable media: Sustainable multidimensional media contents (SUMED), Booklet 2, pp. 56-66.* SUMED. https://sumed-project.eu/assets/sumed-booklet2.pdf

Green, T. L. (2013). Teaching (un)sustainability? University sustainability commitments and student experiences of introductory economics. *Ecological Economics 94*, 135–142. https://doi.org/10.1016/j.ecolecon.2013.08.003

Halonen, P., Kuusela, A., & Järvipetäjä , M. (2024). Leading change for sustainability in media organizations: Sustainability at everyday work in three Finnish media organizations: Good practices and future challenges. In M. Maslowska & Ġ. Mallia (Eds.),, *Cases of sustainable media: Sustainable multidimensional media contents (SUMED), Booklet 1,* pp. 34-53. SUMED. https://sumed-project.eu/assets/sumed-booklet1.pdf

Karmasin, M., & Voci, D. (2021). The role of sustainability in media and communications studies' curricula throughout Europe. In *International Journal of Sustainability in Higher Education, 22*(8), 42-68. https://doi.org/10.1108/IJSHE-10-2020-0380

Jha, A. K., & Verma, N. K. (2023). Social media sustainability communication: An analysis of firm behaviour and stakeholder responses. *Information Systems Frontiers 25*, 723–742. https://doi.org/10.1007/s10796-022-10257-6

Leal Filho, W., Levesque, V. R., Salvia, A. L., Paço, A., Fritzen, B., Frankenberger, F., Damke, L. I., Brandli, L. L., Veiga Ávila, L., Mifsud, M., Will, M., Pace, P., Azeiteiro, U. M., & Orlovic Lovren, V. (2021). University teaching staff and sustainable development: An assessment of competences. *Sustainability Science 16*:101–116. https://doi.org/10.1007/s11625-020-00868-w

Lopera-Mármol, M., & Jiménez-Morales, M. (2021). Green shooting: Media sustainability, a new trend. *Sustainability*, *13*(6), 3001. https://doi.org/10.3390/su13063001

Maslowska, M. (2024). Malta case study: Exploring sustainable filmmaking in screenwriting. In M. Maslowska & Ġ. Mallia (Eds.), *Cases of sustainable media: Sustainable multidimensional media contents (SUMED), Booklet 1,* pp. 54-59. SUMED. https://sumed-project.eu/assets/sumed-booklet1.pdf

Ralph, M., & Stubbs, W. (2014). Integrating environmental sustainability into universities. *Higher Education, 67,* 71–90. https://doi.org/10.1007/s10734-013-9641-9

Reid, A., & Petocz, P. (2006). University lecturers' understanding of sustainability. *Higher Education 51,* 105–123. https://doi.org/10.1007/s10734-004-6379-4

Revans, R. (1982). The origins and growth of action learning. *Industrial and Commercial Training*, *14*(7), pp. 248-249. https://doi.org/10.1108/eb003898

Sclavi, M. (2014). *Avventure Urbane: Progettare la città con gli abitanti*. Milano: Elèuthera.

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. https://sdgs.un.org/2030agenda.

Vygotsky, L. (1978). *Mind in society*. London: Harvard University Press.

Weder, F., Rademacher, L., & Schmidpeter, R. (Eds.). (2023). *CSR Communication in the Media: Media Management on Sustainability at a Global Level.* Cham, Switzerland: Springer.

Author details

Ġorġ Mallia
University of Malta
gorg.mallia@um.edu.mt

Monika Maslowska
University of Malta
monika.m.maslowska@um.edu.mt

LEVERAGING AI FOR PERSONALIZED INSTRUCTION IN HIGHER EDUCATION: INITIAL FINDINGS FROM THE LEADER AI PROJECT

Apostolos Kostas, Dimitris Spanos, Filippos Tzortzoglou, & Alivisos Sofos
University of the Aegean
GREECE

Abstract

This paper presents preliminary findings of the LEADER AI, an Erasmus+ project aimed at equipping Higher Education Institutions (HEIs) with guidelines and resources for leveraging AI-based and data-driven tools for personalized instruction. Drawing upon a multifaceted research approach, this study conducted desk research across four diverse countries (Greece, Malta, Italy, and Denmark), as well as focus group and survey research in Greece. Both research tools were designed to elucidate the affordances and challenges associated with the adoption of AI-based and data-driven tools. Results provide valuable perspectives on the opportunities, barriers, and ethical considerations inherent in employing AI-based solutions for personalized instruction in HEIs.

Introduction

The LEADER AI project aims to build the capacity of Higher Education Institutions (HEIs) to personalize digital learning through AI-based tools and data-driven decision making, in order to respond to students' needs, strengths, and skills, through the proper exploitation of advanced technologies. The project's specific objectives are: a) raise awareness about the role of Learning Analytics (LA) and Artificial Intelligence (AI) for personalisation of learning in HE, considering ethical issues; b) develop hands-on resources for the adoption of AI-based and data visualization tools for personalized learning in HE; c) build the digital and pedagogical competences of HE faculty and staff in customizing their teaching using AI-based and data visualization tools; and d) improve the supply of high quality digital learning opportunities in HE. LEADER AI will develop a toolkit with practical guidelines, scenario-based training, and a MOOC with digital resources on how HEIs can use AI-based and data-driven tools and approaches for personalized instruction. As part of the development of the toolkit, the consortium has conducted desk and field research in Cyprus, Greece, Romania, and Portugal. This paper presents the Greek National Report and explores the current state of AI integration in higher education, by employing desk research, focus groups, and questionnaires to uncover the benefits and challenges of AI-driven personalized learning. The paper is organized as follows: the initial section provides a theoretical overview of AI and LA in educational contexts; subsequently, the methodology employed in this research is delineated, leading into the presentation of findings; and finally, the last section deliberates upon these results, drawing conclusions concerning the application of AI and LAs in Higher Education in Greece.

Theoretical Background

Despite the growing realization of the potential for AI in education (AIED), influenced by educational evidence-based policy (OECD, 2021), it has arguably only now transitioned from experiment to practice in educational settings. Moreover, AI is subject of an extensive public discourse, especially after the introduction of ChatGPT and DALL-E, which have both captured our imagination and shocked in equal measure, requiring education to respond to generative AI's growing capabilities. The uptake of these tools has given rise to a debate in education about readiness, ethics, trust, impact, and added value of AI, as well as the need for governance, regulation, research, and training to cope with the speed and scale at which AI is transforming teaching and learning (Bond et al., 2023). As Bond et al. (2023) summarizes in their meta-systematic review of AI in Higher Education, the evolution of AIED can be traced back several decades, exhibiting a rich history of intertwining educational theory and emergent technology. As the field matured through the 1990s and into the 2000s, research explored various facets of AIED such as intelligent tutoring systems, adaptive learning environments, and supporting collaborative learning environments.

After the 2010s, the synergies between AI tools and educational practices have further intensified, boosted by advancements in machine learning, natural language processing, and cognitive computing. During this period, researchers explored chatbots for student engagement, automated grading, and feedback, predictive analytics for student success, and various adaptive platforms for personalized learning, facing various challenges and dilemmas, like the ethical use of AI. In order to gain further understanding of the applications of AI in higher education, and to provide guidance to the field, Zawacki-Richter et al. (2019) developed a typology (Figure 1), classifying research into four broad areas: 1) profiling and prediction; 2) intelligent tutoring systems; 3) assessment and evaluation; and 4) adaptive systems and personalisation.

"Personalisation" is conceptualized as a process where students consciously assume responsibility for their learning process, self-assessing and reorganizing their learning paths and as such, personalized learning is conceived as an individual, student-focused learning, where students become central agents of their learning process (Tsai et al., 2020).

Figure 1

AIED Typology (Zawacki-Richter et al., 2019)

Profiling & Prediction	Intelligent Tutoring Systems	Assessment & Evaluation	Adaptive Systems & Personalization
-Admission decisions & course scheduling -Drop-out & retention -Student models & academic achievement	-Teaching course content -Diagnosing strengths & automated feedback -Curating learning materials based on student needs -Facilitating collaboration between learners -Teacher's perspective	-Automated grading -Feedback -Evaluation of student understanding, engagement & academic integrity -Evaluation of teaching	-Teaching course content -Recommending personalised content -Supporting teachers in learning and teaching design -Using academic data to monitor & guide students -Representation of knowledge

Personalized Learning (PL) is basically the process of modifying teaching and learning based on the learners' profile, in advance, or as the learning process unfolds "a range of learning experiences, instructional approaches, and academic support strategies intended to address the specific learning needs, interests, aspirations, or cultural backgrounds of individual students" (Holmes et al., 2018, p. 15). For example, PL is linked with supervised learning that focuses on students' learning habits and adaptation to new ones (Topîrceanu & Grosseck, 2017), use of adaptive learning environments (Renz et al., 2020), the creation and/or adaption of individualized learning plans for students (Bucea-Manea-Țoniș et al., 2022), the provision of recommendations based on students' psychological profile (Brdnik et al., 2022), and the adaptation of chatbots to the users' language level (Belda-Medina & Calvo-Ferrer, 2022).

When automated technology is used, technology is responsible for the adaptation, where participants' activity and interactions are available through Learning Management System (LMS). Keller et al. (2019) suggested that individually tailored learning outcomes can be achieved through LA that provide students with performance feedback and learning recommendations by uncovering patterns in their individual learning behaviors. With a specific focus on LA in HE and its link to study success, LA are defined as "the use, assessment, elicitation and analysis of static and dynamic information about learners and learning environments, for the near real-time modeling, prediction and optimisation of learning processes, and learning environments, as well as for educational decision-making" (Ifenthaler, 2015, p. 447).

Research Methodology

To address the project objectives, we adopted a mixed-method research to elucidate the affordances and challenges of AI-based and data-driven tools for personalized instruction. Initially, desk research across four countries (Greece, Malta, Italy, and

Denmark) was conducted to understand the current landscape of AI in HEIs and provide answers to the following research questions:

- *What methodologies are followed to investigate the application of PL with AI and data-driven technologies?*
- *What types of AI and data-driven technologies are used and in what way, to implement PL?*
- *Which benefits and challenges of PL with AI and data-driven technologies were reported?*

The desk research focused on research papers published from 2018-2023 in the SCOPUS, EBSCO, Semantic Scholar, and Google Scholar databases. Desk research studies were predominantly from Greece (6), followed by Italy (2), Malta (2), and Denmark (2). Additionally, the research methodology incorporated a focus group session with semi-structured questions involving eight Higher Education staff members and a questionnaire distributed to 50 respondents affiliated with Greek HEIs (teaching and research staff, e-Learning experts, instructional designers, leaders), with 86% of them having a PhD degree.

Results

What methodologies are followed to investigate the application of PL with AI and data-driven technologies?

In the desk research, most studies utilized student-provided information, either directly (e.g., registration), or indirectly (e.g., Moodle). Montebello (2021) employed implicit and explicit data, including browsing history and learning analytics within the platform. Gkontzis et al. (2018) analyzed data from the Hellenic Open University's Moodle, encompassing essays, e-quizzes, and forum threads. Iatrellis et al. (2021) and Agrusti et al. (2020) sourced data from university databases, Carannante et al. (2021) measured students' activity, while Moşteanu (2022) employed qualitative interviews.

Focus group answers revealed a moderated familiarity with concepts like PL, LA, and AI, and a lack of empirical interventions in Greek HEIs, while current practices focus on e-quizzes, course monitoring and use of selective-release criteria with platforms like Moodle. Concerns regarding institutional guidance, potential behavior control, and documented learning benefits emerged, as well. Finally, participants recognized the potential value of educational data, mostly in terms of monitoring rather than personalizing e-courses.

Survey respondents demonstrated a strong familiarity with the terms "personalized learning" and "educational data" and moderate familiarity with "learning analytics" and "artificial intelligence" (Figure 2). Reasons of the low usage (Figure 3) is the lack of university support (33/50, 66%), lack of training (33/50, 66%), lack of university policy (25/50, 52%), lack of adequate infrastructure (23/50, 46%), lack of time (18/50, 36%) and lack of skills (17/50, 34%). Also, 3/50 (6%) of the respondents stated that they use these technologies as a university policy, 29/50 (58%) as beneficial for their students, and 26/50 (52%) for pedagogical purposes. Moreover, they stated that they are using PL and LA for self-assessment, supervised learning, statistical analysis, chatbots, research, and predictive analytics.

Figure 2

Levels of Familiarity with PL, LA, AI and Educational Data

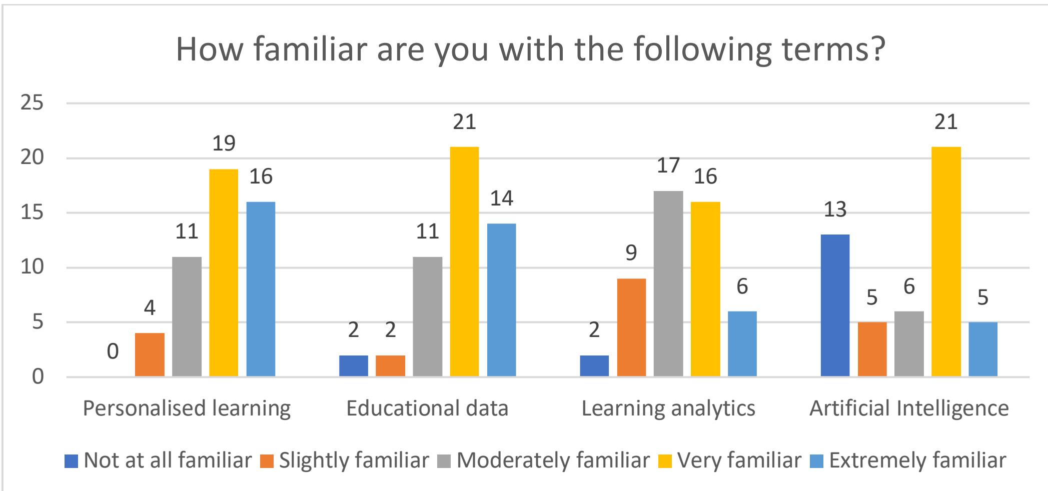
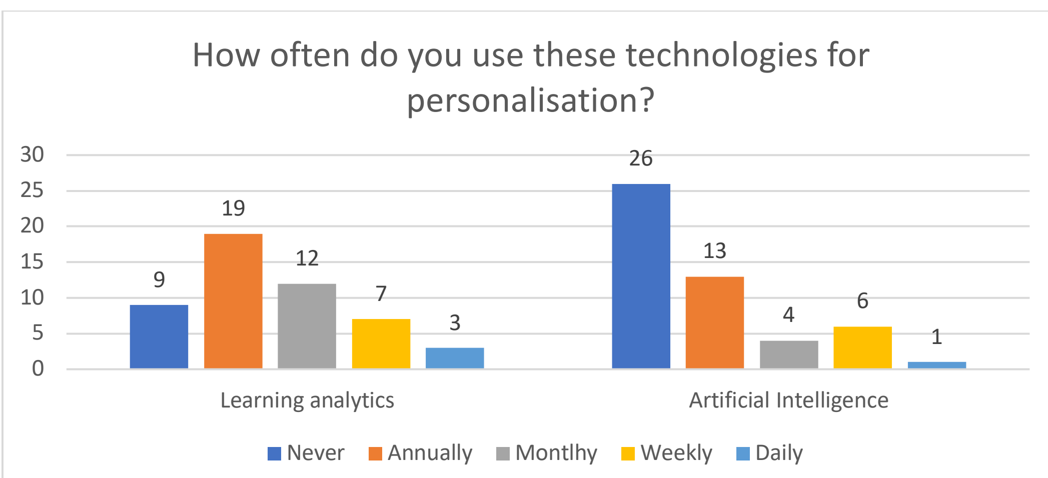


Figure 3

Use of PL and LA for Personalization



What types of AI and data-driven technologies are used and in what way, to implement PL?

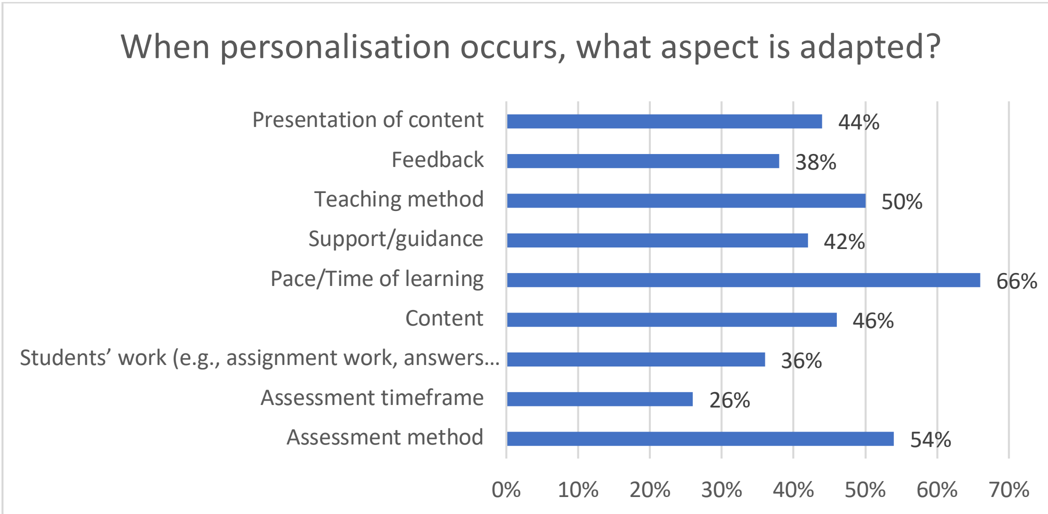
In the desk research, Gkontzis et al. (2018) reported Moodle's Learning Analytics Dashboards for performance visualization. Algayres & Triantafyllou (2020) proposed a personalized adaptive learning model and Iatrellis et al., (2021) used supervised learning. Carannante et al. (2021) employed PLS Path Modeling to analyze the relationship among performance, engagement, and learning. The study by Montebello (2021) focused on a PL environment through the integration of AI machine learning to address e-learning issues such as isolation, motivation, and self-determination. Agrusti et al. (2020) explored dropout prediction using different sets of features related to academic and administrative data.

Participants in the focus group recognised the potential benefits of LA for self-improvement and reflective practices and recommended utilizing log data from LMS and virtual environments, acknowledging their significance. On the other hand, participants stated that actual utilization of these technologies for personalization still remains low due to skepticism and concerns about data privacy and students' discomfort. Participants envisioned AI applications such as automated responses and feedback, yet raised concerns over their credibility and ethical implications, emphasizing the need for responsible implementation. Ethical considerations, technological readiness, and the necessity for practical training were not reported as crucial aspects. Moreover, the need for transparent guidelines for the integration of AI and LA in education were reported as essential for ensuring ethical and effective implementation.

Survey results showed that decision-making is mainly a teacher-driven approach (28/50, 56%) mainly informed by performance metrics (38/50, 76%), data patterns (24/50, 48%) and educational goals (20/50, 40%). Respondents stated that adaptations could occur in the whole course (20/50, 40%), before the instruction (14/50, 28%) and during instruction (15/50, 30%), with adjustments to pace, assessment methods, teaching strategies, content delivery, support and feedback mechanisms (Figure 4).

Figure 4

Types of Course Adaptation



Which are the benefits and challenges of PL with AI and data-driven technologies?

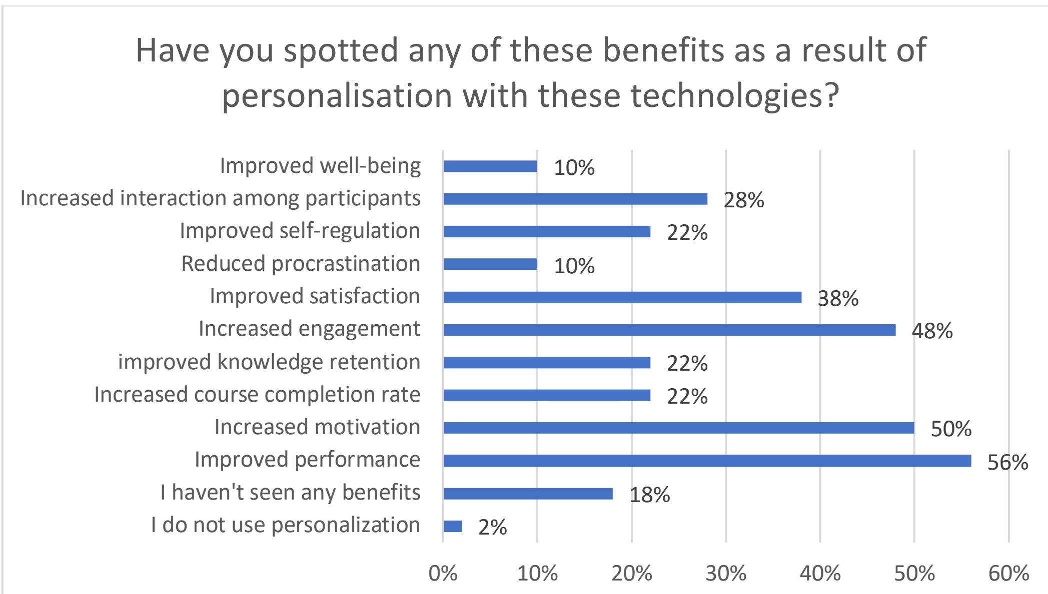
Moşteanu (2022) highlighted the potential of AI and machine learning in various educational aspects, such as admission processes, attendance monitoring, personalized learning, and assisting in evaluation processes. Gkontzis et al. (2018) noted that student participation indicators correlate with educational progress and higher grades, aiding tutors in understanding student characteristics affecting academic achievement. Demetriadis et al. (2018) emphasized benefits like increased online engagement, motivation, innovative pedagogical approaches, and reduced dropout rates through LA. Montebello (2021) suggested compatibility of AI, social networks, and learners' portfolios in enhancing online education. Carannante et al. (2021) highlighted the importance of user actions, frequency, and time spent, as indicators of engagement and study organization. Time-based indicators improved performance measurement, but models combining administrative and academic career features yielded better results than those using administrative features alone.

The results from the focus group pertaining to the benefits and challenges of PL with AI and data-driven technologies revealed a nuanced landscape. While participants highlighted the potential benefits of PL for self-improvement and reflective practices, concerns were raised regarding credibility, ethical implications, and the need for responsible implementation. Machine learning algorithms were identified as promising tools for predictive modeling in student evaluations, although challenges such as data privacy and student discomfort persisted.

Various benefits were reported from the survey, including enhanced academic performance, motivation, engagement, and satisfaction, alongside increased interaction, completion rates, knowledge retention, and self-regulation (Figure 5). Finally, in the open question about challenges of personalization, respondents mentioned increased workload, human isolation, incorrect or irrelevant data, and the lack of technical support, policies, training and infrastructure.

Figure 5

Perceived benefits of personalization



Conclusions

This study aimed to investigate the adoption of LA, AI, data-driven technologies and PL in HEIs in Greece, as part of a transnational research in the framework of the LEADER AI project, conducting desk research as well as focus group and survey research. Results revealed a diverse landscape of methodologies, technologies, and outcomes.

Desk research indicates various methodologies employed, primarily centered around leveraging student-provided information and traditional research techniques rather than direct integration of AI and LA into PL environments. While AI and data-driven technologies are recognized for their potential benefits, such as higher retention rates and enhanced assessment, their integration into PL remains limited, primarily utilized for research purposes rather than practical implementation. Use of these technologies is still in its early stages, with various benefits and challenges associated with these approaches. The studies highlighted the potential of these technologies to provide insights into student motivation, studying patterns, engagement, and performance, as well as to offer personalised support and feedback based on student progress, preferences, and goals. However, the studies also emphasised the need for careful consideration and further exploration of the capabilities, accuracy, ethical implications, and infrastructure requirements of these technologies. Findings from focus group and survey further underscore the cautious adoption of AI and data-driven technologies in PL contexts, while findings from the online survey suggest a familiarity with PL concepts among participants. Despite recognizing the potential benefits, participants expressed concerns regarding credibility, ethical implications, responsible implementation and utilization, due to factors such as lack of support, training, and policy.

Even though results are not generalizable due to limitations to the sample size, this study may contribute to the growing discourse on AI in education by offering insights derived from a multi-country study, thereby informing the development of tailored strategies and interventions to harness the potential of AI for enhancing personalized learning experiences in HEIs. The implication of the findings for policy, practice, and future research are discussed in light of advancing the educational landscape towards greater inclusivity, innovation, and effectiveness through AI integration.

Overall, the research underscores the importance of addressing these challenges to fully realize the potential of AI and data-driven technologies in personalized learning contexts. The findings call for concerted efforts to enhance institutional support, policy frameworks, and technological readiness to facilitate seamless integration. By addressing these challenges, HEIs can harness the transformative potential of AI and data-driven technologies to enhance personalized learning experiences and achieve improved student outcomes.

Acknowledgement

This work was funded by the European Commission, under project LEADER AI - LEAarning analytics and AI for personaliseD lEaRning, Erasmus+, 2022-1-CY01-KA220-HED-000086763, in the context of WP2 LEADER AI Toolkit.

References

Agrusti, F., Mezzini, M., & Gianmarco, B. (2020). Deep learning approach for predicting university dropout: A case study at Roma Tre University.

Journal of E-Learning and Knowledge Society, *16*, 44-54. https://doi.org/10.20368/1971-8829/1135192

Algayres, M., & Triantafyllou, E. (2020). An Educational Model for Integrating Game-Based and PBL in Data-Driven Flipped Classrooms. In E. Popescu, T. Hao, T.-C. Hsu, H. Xie, M. Temperini, & W. Chen (Eds.), *Emerging Technologies for Education* (pp. 145–154). Springer. https://doi.org/10.1007/978-3-030-38778-5_17

Belda-Medina, J., & Calvo-Ferrer, J. R. (2022). Using chatbots as AI conversational partners in language learning. *Applied Sciences*, *12*(17), 8427. https://doi.org/10.3390/app12178427

Bond, M., Khosravi, H., & De Laat, M., Bergdahl, N., Negrea, V., Oxley, E., Pham, P., Chong, S.W., & Siemens, G. (2023). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, *21*, 4. https://doi.org/10.1186/s41239-023-00436-z

Brdnik, S., Šumak, B., & Podgorelec, V. (2022). Aligning learners' expectations and performance by learning analytics system with a predictive model. *ArXiv, abs/2211.07729*. https://doi.org/10.48550/arxiv.2211.07729

Bucea-Manea-Țoniş, R., Kuleto, V., Gudei, S.C.D., Lianu, C., Lianu, C., Ilić, M. P., & Păun. D. (2022). Artificial intelligence potential in higher education institutions enhanced learning environment in Romania and Serbia. *Sustainability*, *14*(10), 5842. https://doi.org/10.3390/su14105842

Carannante, M., Davino, C., & Vistocco, D. (2021). Modelling students' performance in MOOCs: A multivariate approach. *Studies in Higher Education*, *46*(11), 2371–2386. https://doi.org/10.1080/03075079.2020.1723526

Demetriadis, S., Karakostas, A., Tsiatsos, T., Caballé, S., Dimitriadis, Y., Weinberger, A., Papadopoulos, P. M., Palaigeorgiou, G., Tsimpanis, C., & Hodges, M. (2018). Towards integrating conversational agents and learning analytics in MOOCs. In L. Barolli, F. Xhafa, N. Javaid, E. Spaho, & V. Kolici (Eds.), *Advances in Internet, Data & Web Technologies* (EIDWT 2018) (pp. 1061–1072). Springer. https://doi.org/10.1007/978-3-319-75928-9_98

Gkontzis, A. F., Panagiotakopoulos, C. T., Kotsiantis, S., & Verykios, V. S. (2018). Measuring engagement to assess performance of students in distance learning. *2018 9th International Conference on Information, Intelligence, Systems and Applications (IISA)*, 1–7. Zakynthos, Greece. https://doi.org/10.1109/IISA.2018.8633607

Holmes, W., Anastopoulou S., Schaumburg, H. & Mavrikis, M. (2018). *Technology-enhanced personalised learning: Untangling the evidence.* Robert Bosch Stiftung Gmbh.

Iatrellis, O., Savvas, I. K., Fitsilis, P., & Gerogiannis, V. C. (2021). A two-phase machine learning approach for predicting student outcomes. *Education and Information Technologies*, *26*(1), 69–88. https://doi.org/10.1007/s10639-020-10260-x

Ifenthaler, D. (2015). Learning analytics. In J. M. Spector (Ed.), *The SAGE encyclopedia of educational technology* (Vol. 2, pp. 447–451). Sage.

Keller, B., Baleis, J., Starke, C., & Marcinkowski, F. (2019). *Machine learning and artificial intelligence in higher education: a state-of-the-art report on the German university landscape*. Heinrich-Heine-Universität Düsseldorf. https://tinyurl.com/6z7huruw

Montebello, M. (2021). Personalized Learning Environments. *2021 International Symposium on Educational Technology (ISET)*, pp. 134–138. Nagoya, Japan. https://doi.org/10.1109/ISET52350.2021.00036

Moşteanu, N. R. (2022). Machine learning and robotic process automation take higher education one step further. *Romanian Journal of Information Science and Technology*, *25*(1), 92–99. Scopus.

OECD (2021). *AI and the future of skills, volume 1: Capabilities and assessments*. OECD Publishing. https://doi.org/10.1787/5ee71f34-en

Renz, A., Krishnaraja, S., & Gronau, E. (2020). Demystification of artificial intelligence in education – How much AI is really in the educational technology? *International Journal of Learning Analytics and AI for Education*, *2*(1), 14-30. https://doi.org/10.3991/ijai.v2i1.12675

Topîrceanu, A., & Grosseck, G. (2017). Decision tree learning used for the classification of student archetypes in online courses. *Procedia Computer Science*, *112*, 51–60. https://doi.org/10.1016/j.procs.2017.08.021

Tsai, Y. S., Rates, D., Moreno-Marcos, P. M., Muñoz-Merino, P. J., Jivet, I., Scheffel, M., Drachsler, H., Kloos, C. D., & Gašević, D. (2020). Learning analytics in European higher education—Trends and barriers. *Computers and Education*, *155*, 103933. https://doi.org/10.1016/j.compedu.2020.103933

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(39). https://doi.org/10.1186/s41239-019-0171-0

Author Details

Apostolos Kostas,
Dept. of Primary Education, University of the Aegean
Greece
apkostas@aegean.gr

Dimitris Spanos
Dept. of Primary Education, University of the Aegean
Greece
spanosdm@aegean.gr

Filippos Tzortzoglou
Dept. of Primary Education, University of the Aegean
Greece
filippostz@aegean.gr

Alivisos Sofos
Dept. of Primary Education, University of the Aegean
Greece
lsofos@aegean.gr

THE PERCEPTIONS OF SLOVENIAN HIGHER EDUCATION STUDENTS ON CHATGPT: A COMPARISON WITH GLOBAL TRENDS

Aleksander Aristovnik, Lan Umek, and Dejan Ravšelj*
University of Ljubljana
SLOVENIA

Abstract

The launch of ChatGPT in November 2022 profoundly impacted higher education, quickly gaining popularity among students. Therefore, this paper aims to examine the perceptions of Slovenian higher education students on ChatGPT compared to global trends. The results, based on data from 23,218 students, including 452 students studying in Slovenia, collected between October 2023 and February 2024, reveal that students use ChatGPT for brainstorming, summarizing, and research, with Slovenian students favouring it for academic writing. Moreover, ethical concerns include cheating, inaccuracy, and plagiarism, highly emphasized by Slovenian students. Most students support regulation, though Slovenian students are less supportive.

Introduction

The introduction of the conversational chatbot ChatGPT in November 2022 represented a pivotal moment for artificial intelligence applications in higher education. Created by OpenAI (San Francisco, CA), ChatGPT quickly gained popularity among students due to its natural language processing capabilities, enabling seamless user interactions (Alessandri-Bonetti et al., 2024; Mohmad, 2023). While the primary function of ChatGPT is to mimic human conversation, it is highly versatile, offering numerous possibilities for various tasks (Boubker, 2024; Das & Madhusudan, 2024). As one of the most advanced and rapidly growing consumer artificial intelligence applications, ChatGPT has drawn the attention of educational professionals worldwide, eliciting both excitement and skepticism within higher education settings (Tlili et al., 2023; Twinomurinzi & Gumbo, 2023).

Some educational professionals advocate for the integration of ChatGPT to enrich the learning experience (Aristovnik et al., 2024; Farrokhnia et al., 2023; Rudolph et al., 2023; Umek et al., 2023). ChatGPT provides numerous benefits that can significantly improve learning in higher education. It offers real-time feedback and guidance, helping students stay focused and address issues as they occur. Additionally, its availability across various platforms, including websites, smartphone apps, and messaging services, and enables students to use the tool at their convenience, promoting flexible learning. Moreover, ChatGPT delivers personalized support tailored to each student's preferences and goals and can enhance the utilization of open educational resources (Firat, 2023; Michalon & Camacho-Zuñiga, 2023). Consequently, ChatGPT is believed to have substantial implications for learning outcomes, including the development of employability skills (Ravšelj & Žabkar, 2024).

Conversely, some educators are wary of incorporating ChatGPT in higher education due to several ethical concerns. Major issues include data privacy, as unauthorized access demands strict adherence to regulatory standards. Additionally, algorithmic bias stemming from historically biased datasets requires the use of diverse data sources and regular audits to safeguard student experiences. While ChatGPT can aid in personalized learning, it might reduce student engagement and self-efficacy, necessitating a balance between artificial intelligence autonomy and human oversight. Furthermore, ChatGPT could facilitate plagiarism, requiring robust academic honesty policies, plagiarism detection tools, and originality-promoting assessment methods. Finally, the risk of AI "hallucinations" or misinformation underscores the importance of rigorous verification of artificial intelligence-generated content to maintain educational integrity (Williams, 2024).

Despite some research attempts exploring the factors influencing student perceptions of ChatGPT, studies specifically highlighting the impact of socio-demographic characteristics remain limited. Preliminary findings suggest that attitudes toward ChatGPT are significantly shaped by variables such as country of residence, age, type of university, and recent academic performance (Abdaljaleel et al., 2024). Therefore, the paper aims to compare the perceptions of Slovenian higher education students on ChatGPT with those of their international counterparts. The paper primarily focuses on aspects related to ChatGPT usage, including the ethical concerns surrounding its use and its regulation. More specifically, the paper seeks to answer the following research questions:

- RQ1: Which tasks do students most frequently perform with the help of ChatGPT?
- RQ2: How do students perceive the ethical concerns associated with using ChatGPT?
- RQ3: How do students perceive the regulation of ChatGPT usage?

By addressing these research questions, this paper offers novel, evidence-based insights into the perceptions of higher education students on ChatGPT, comparing Slovenian students with global trends. The results are highly valuable for policymakers and educators as they guide the responsible incorporation of ChatGPT into higher education settings. Namely, key findings suggest that students mainly use ChatGPT for brainstorming, summarizing, and research assistance, with ethical concerns about cheating and reduced learning being prominent. While there is strong support for regulating ChatGPT, Slovenian students are less supportive of these measures compared to their international counterparts. The rest of the paper is organized as follows: the next section details the methodology of the study, including data collection techniques and analytical procedures. The subsequent section presents the main findings, addressing the research questions. The final section concludes the paper by summarizing the main findings and discussing their broader implications.

Methodology

The data were gathered via the global "ChatGPT Student Survey", launched by the Faculty of Public Administration at the University of Ljubljana, concentrating on "Students' Perception of ChatGPT". The online survey was created in English and subsequently translated into six more languages: Italian, Spanish, Turkish, Japanese, Arabic, and Hebrew. It consisted of closed-ended questions addressing various aspects related to the opportunities and challenges ChatGPT presents for students. The survey targeted higher education students who are at least 18 years old and have the legal capacity to provide informed, voluntary consent to participate in this voluntary and anonymous survey (Aristovnik et al., 2024). The data collection took place from October 2023 to February 2024 using a convenience sampling strategy, which involved promoting the survey in classrooms and through advertisements on university communication systems. This practical approach provided easy access to potential students who were readily available and willing to participate in the survey (Boubker, 2024; Sarstedt et al., 2017). Despite the limited generalizability of the convenience sample, this issue is, to some extent, mitigated by ensuring sample diversity and using a large sample size (Jager et al., 2017).

The questionnaire included various sections directly and indirectly related to the context of ChatGPT, covering topics such as knowledge and experiences, capabilities, ethical governance and concerns, satisfaction and attitude, study issues and outcomes, skills development, labour market and skills mismatch, emotions, study and personal information, and general reflections. Individual survey items were measured on a 5-point Likert scale ranging from 1 (e.g., strongly disagree) to 5 (e.g., strongly agree) (Aristovnik et al., 2024). Due to the specific focus of the paper on comparing Slovenian students with their international counterparts from other regions, the paper primarily examines aspects related to ChatGPT usage, including the ethical concerns surrounding its use and its regulation. Regions and countries have specific factors, such as cultural attitudes towards technology, educational priorities, and regulatory environments, which often influence the usage of digital technologies (Abdaljaleel et al., 2024).

The collected data were analyzed using two distinct statistical approaches. First, descriptive statistics (percentage of students who answered with the highest two responses on the 5-point Likert scale) were computed for the entire sample of students, as well as for students from Slovenia and international students from other regions. This analysis helped identify the most and least prevalent opportunities and challenges associated with ChatGPT in the selected aspects studied. Second, an independent-sample t-test was conducted to explore mean differences between students from Slovenia and their international counterparts from other regions. This parametric statistical technique is considered a very robust method and is the most commonly used for detecting differences in means between two groups (Rasch et al., 2007).

Results

By the end of February 2024, a total of 23,218 students, including 452 students studying in Slovenia, had participated in the survey. As students were not required to complete the entire questionnaire, the number of responses per question may vary due to missing values. Table 1 provides the socio-demographic characteristics of the survey participants. Notably, the majority of students were female (58.8%), studying full-time (85.3%), and enrolled in undergraduate programs (83.4%). Regarding fields of study, most students were in social sciences (41.4%), followed by applied sciences (34.5%), with fewer students in arts and humanities (12.1%) and natural and life sciences (12.0%). Additionally, most students were engaged in either traditional (47.3%) or blended (43.2%) learning formats and used the free version of ChatGPT-3.5 (88.6%).

The overall usage of ChatGPT among students showed a diverse range of applications, with the most common tasks being brainstorming, summarizing, and research assistance, while academic writing and study assistance also saw significant usage, although less frequently (Boubker, 2024). Conversely, ChatGPT was least used by students for professional writing and creative writing. Comparatively, Slovenian students tended to use ChatGPT slightly less for tasks like brainstorming and summarizing but more for academic writing than their international counterparts (Figure 1). However, they reported significantly lower usage for study assistance (mean diff = -0.136, $p = 0.063$), personal assistance (mean diff = -0.181, $p = 0.011$), proofreading (mean diff = -0.251, $p < 0.001$) and professional writing (mean diff = -0.216, $p = 0.001$), with other applications showing only minor differences.

Table 1

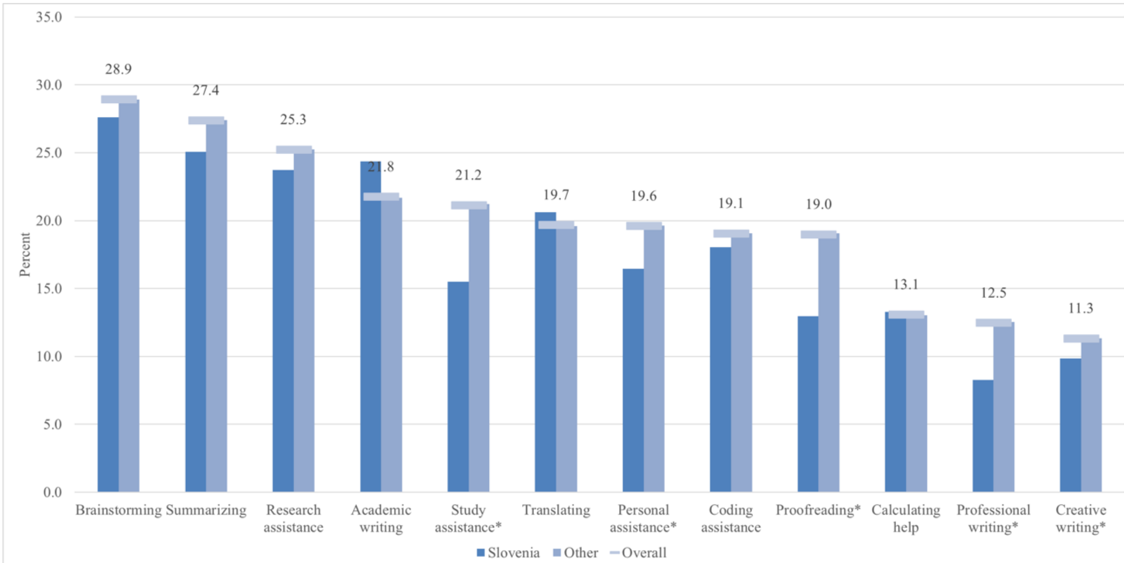
Socio-Demographic Characteristics of the Survey Participants

Socio-demographic characteristics	Number (#)	Share (%)
Gender		
Male	9346	41.2
Female	13365	58.8
Student status		
Full-time	19409	85.3
Part-time	3354	14.7
Level of study		
Undergraduate	18935	83.4
Postgraduate	2867	12.6
Doctoral	912	4.0
Field of study		
Arts and humanities	2740	12.1
Social sciences	9356	41.4
Applied sciences	7809	34.5
Natural and life sciences	2717	12.0
Mode of study		
Traditional learning	10754	47.3
Online learning	2159	9.5
Blended learning	9833	43.2
Version of ChatGPT		
ChatGPT-3.5	14120	88.6
ChatGPT-4.0	525	3.3
ChatGPT-3.5 and 4.0	1284	8.1

Source: Authors’ calculations based on ChatGPT Student Survey.

Figure 1

Usage of ChatGPT for Individual Tasks (% of Students Using ChatGPT Often or Always)



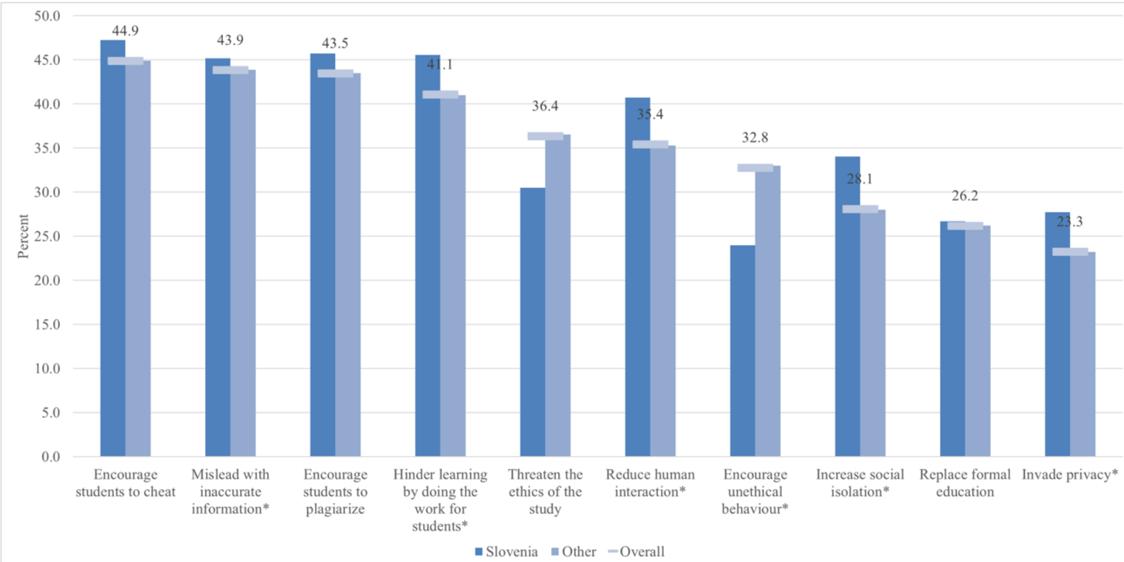
Note: Items are sorted in descending order based on their overall %. An asterik (*) indicates a statistically significant result of the t-test ($p \leq 0.1$).

Source: Authors' calculations based on ChatGPT Student Survey.

Moreover, students expressed several ethical concerns regarding ChatGPT, primarily focusing on its potential to encourage cheating, mislead with inaccurate information, promote plagiarism, and hinder learning by doing the work for students. There were also worries about threatening the ethics of study, reducing human interaction, and encouraging unethical behaviour. This is also in line with previous research that highlighted the challenges of using ChatGPT for unethical purposes, such as plagiarism of intellectual property or cheating (Hasanein & Sobaiih, 2023). Compared with their international counterparts, Slovenian students exhibited higher levels of concern in most of the presented elements, except for threats to the ethics of study and encouraging unethical behaviour (mean diff = -0.179, p = 0.007), with the latter being significantly less pronounced among Slovenian students (Figure 2).

Figure 2

Ethical Concerns About ChatGPT (% of Students Who Agree or Strongly Agree with the Selected Ethical Concerns)



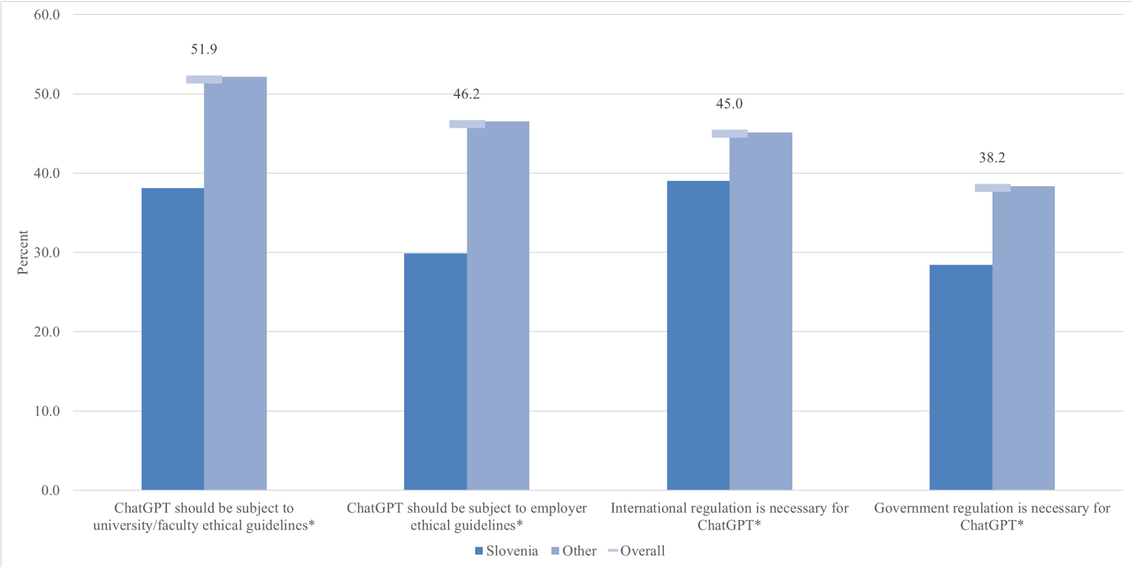
Note: Items are sorted in descending order based on their overall %. An asterik (*) indicates a statistically significant result of the t-test ($p \leq 0.1$).

Source: Authors' calculations based on ChatGPT Student Survey.

Finally, there was substantial support among students for regulating ChatGPT, with a majority agreeing that it should be subject to university or faculty ethical guidelines as well as employer ethical guidelines (Figure 3). There was also considerable support for international and government regulation. This aligns with the opinion that the development of ChatGPT technology should be carefully regulated to ensure that its applications do not have adverse societal impacts (Yu, 2023). However, Slovenian students showed significantly less support for these regulatory measures compared to their international peers from other regions. They were less likely to agree with university or faculty ethical guidelines (mean diff = -0.346, $p < 0.001$), employer ethical guidelines (mean diff = -0.336, $p < 0.001$), international regulations (mean diff = -0.115, $p = 0.066$), and government regulations (mean diff = -0.198, $p = 0.003$), indicating a notable regional difference in the perceived need for regulating ChatGPT.

Figure 3

Regulation of ChatGPT Usage (% of Students Who Agree or Strongly Agree with Selected Solutions for Regulation)



Note: Items are sorted in descending order based on their overall %. An asterik (*) indicates a statistically significant result of the t-test ($p \leq 0.1$).

Source: Authors' calculations based on ChatGPT Student Survey.

Conclusion

The launch of ChatGPT in November 2022 had a profound impact on higher education, rapidly becoming popular among students due to its capability to engage in natural language conversations. Accordingly, this paper aims to examine the perceptions of Slovenian higher education students on ChatGPT, comparing them with global trends. The results reveal the following. First, students primarily use ChatGPT for brainstorming, summarizing, and research assistance. Slovenian students use it more for academic writing but less for brainstorming and summarizing compared to their international peers. Professional and creative writing are the least common uses. Second, students have ethical concerns about ChatGPT, including its potential to encourage cheating, provide inaccurate information, promote plagiarism, and hinder learning. Slovenian students are particularly concerned about cheating and reduced learning but are less worried about ethical threats and unethical behaviour compared to international students. Finally, there is substantial support among students for regulating ChatGPT through university, faculty, employer, international, and government guidelines. However, Slovenian students are less supportive of these regulatory measures compared to their international counterparts.

Future research could involve conducting longitudinal studies to track changes in students' perceptions of ChatGPT over time, as well as expanding the research to include the perspectives of educators. One significant limitation of the paper should be highlighted. Most of the questionnaire elements were based on students' self-reports. This method is often intricate, necessitating both recall and introspection, which could introduce recall bias and social desirability bias due to the self-reported nature of the data (Aristovnik et al., 2020; Ravšelj & Žabkar, 2024). Despite this, the paper's findings enhance the current scientific understanding of ChatGPT's potential and provide educators and policymakers with evidence-based recommendations for the future advancement of higher education.

Acknowledgements

The authors acknowledge the exceptional assistance of numerous international partners in translating the questionnaire and/or collecting data within the CovidSocLab project (https://www.covidsoclab.org/chatgpt-student-survey/), which served as a working platform for collaboration. Moreover, the authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P5-0093 and project No. Z5-4569). Finally, in the preparation of this manuscript, the authors utilized ChatGPT, version 4, developed by OpenAI, for limited and supplementary purposes. Specifically, ChatGPT was employed to assist with checking the grammar, enhancing clarity, and polishing the language in certain sections of the manuscript. It must be stressed that the role of the ChatGPT was minor and purely supportive in nature. The core content of the manuscript, including all scientific interpretations, conclusions, and critical revisions, is the exclusive output of the human authors. ChatGPT did not contribute to the intellectual content or scientific insights of the manuscript.

***Other (co)authors:** Partners of the International Consortium, https://www.covidsoclab.org/chatgpt-student-survey/partners/.

References

Abdaljaleel, M., Barakat, M., Alsanafi, M., Salim, N. A., Abazid, H., Malaeb, D., Mohammed, A. H., Hassan, B. A. R., Wayyes, A. M., Farhan, S. S., El Khatib, S., Rahal, M., Sahban, A., Abdelaziz, D. H., Mansour, N. O., AlZayer, R., Khalil, R., Fekih-Romdhane, F., Hallit, R., Hallit, S., & Sallam, M. (2024). A multinational study on the factors influencing university students' attitudes and usage of ChatGPT. *Scientific Reports*, *14*(1), 1983. https://doi.org/10.1038/s41598-024-52549-8

Alessandri-Bonetti, M., Liu, H. Y., Giorgino, R., Nguyen, V. T., & Egro, F. M. (2024). The first months of life of chatgpt and its impact in healthcare: a bibliometric analysis of the current literature. *Annals of Biomedical Engineering*, *52*, 1107-1110. https://doi.org/10.1007/s10439-023-03325-8

Aristovnik, A., Keržič, D., Ravšelj, D., Tomaževič, N., & Umek, L. (2020). Impacts of the COVID-19 pandemic on life of higher education students: A global perspective. *Sustainability*, *12*(20), 8438. https://doi.org/10.3390/su12208438

Aristovnik, A., Umek, L., Brezovar, N., Keržič, D., & Ravšelj, D. (2024). The role of ChatGPT in higher education: Some reflections from public administration students. In S. K. S. Cheung, F. L. Wang, N. Paoprasert, P. Charnsethikul, K. C. Li, & K. Phusavat (Eds.), *Technology in education. Innovative practices for the new normal. ICTE 2023. Communications in Computer and Information Science* (Vol. 1974) (pp. 337-349). Springer, Singapore. https://doi.org/10.1007/978-981-99-8255-4_22

Boubker, O. (2024). From chatting to self-educating: Can AI tools boost student learning outcomes? *Expert Systems with Applications*, *238*(A), 121820. https://doi.org/10.1016/j.eswa.2023.121820

Das, S. R., & Madhusudan, J. V. (2024). Perceptions of higher education students towards ChatGPT usage. *International Journal of Technology in Education*, *7*(1), 86-106. https://doi.org/10.46328/ijte.583

Farrokhnia, M., Banihashem, S. K., Noroozi, O., & Wals, A. (2024). A SWOT analysis of ChatGPT: Implications for educational practice and research. *Innovations in Education and Teaching International*, *61*(3), 460-474. https://doi.org/10.1080/14703297.2023.2195846

Firat, M. (2023). How ChatGPT can transform autodidactic experiences and open education? *OSF Preprints*. https://osf.io/preprints/osf/9ge8m

Hasanein, A. M., & Sobaih, A. E. E. (2023). Drivers and consequences of ChatGPT use in higher education: Key stakeholder perspectives. *European Journal of Investigation in Health, Psychology and Education*, *13*(11), 2599-2614. https://doi.org/10.3390/ejihpe13110181

Jager, J., Putnick, D. L., & Bornstein, M. H. (2017). II. More than just convenient: The scientific merits of homogeneous convenience samples. *Monographs of the Society for Research in Child Development*, *82*(2), 13-30. https://doi.org/10.1111/mono.12296

Michalon, B., & Camacho-Zuñiga, C. (2023). ChatGPT, a brand-new tool to strengthen timeless competencies. *Frontiers in Education*, *8*, 1251163. https://doi.org/10.3389/feduc.2023.1251163

Mohmad, P. (2023, January 19). *How does ChatGPT become popular so quickly and how is it growing.* Analytics Insight.

https://www.analyticsinsight.net/how-does-chatgpt-become-popular-so-quickly-and-how-is-it-growing/

Rasch, D., Teuscher, F., & Guiard, V. (2007). How robust are tests for two independent samples? *Journal of Statistical Planning and Inference*, *137*(8), 2706-2720. https://doi.org/10.1016/j.jspi.2006.04.011

Ravšelj, D., & Žabkar, J. (2024). The potential of ChatGPT in developing employability skills of public administration students: Empirical evidence from Slovenia. In *IIAS Conference 2024: 26-29 February 2024, Mombasa, Kenya*. International Institute of Administrative Sciences.

Rudolph, J., Tan, S., & Tan, S. (2023). ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? *Journal of Applied Learning & Teaching, 6*(1), 342-363. https://doi.org/10.37074/jalt.2023.6.1.9

Sarstedt, M., Bengart, P., Shaltoni, A. M., & Lehmann, S. (2017). The use of sampling methods in advertising research: A gap between theory and practice. *International Journal of Advertising*, *37*(4), 650-663. https://doi.org/10.1080/02650487.2017.1348329

Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning Environments*, *10*, 15. https://doi.org/10.1186/s40561-023-00237-x

Twinomurinzi, H., & Gumbo, S. (2023). ChatGPT in Scholarly Discourse: Sentiments and an Inflection Point. In A. Gerber & M. Coetzee, M. (Eds.), *South African Institute of Computer Scientists and Information Technologists (*SAICSIT 2023): *Communications in Computer and Information Science*, vol 1878 (pp. 258-272). Springer, Cham. https://doi.org/10.1007/978-3-031-39652-6_17

Umek, L., Brezovar, N., Keržič, D., & Ravšelj, D. (2023). The perception of public administration students on ChatGPT. In *EGPA 2023 Conference: 5-8 September 2023, Zagreb, Croatia*. European Group for Public Administration.

Williams, R. T. (2024). The ethical implications of using generative chatbots in higher education. *Frontiers in Education*, *8*, 1331607. https://doi.org/10.3389/feduc.2023.1331607

Yu, H. (2023). Reflection on whether Chat GPT should be banned by academia from the perspective of education and teaching. *Frontiers in Psychology*, *14*, 1181712. https://doi.org/10.3389/fpsyg.2023.1181712

Author Details

Aleksander Aristovnik
Faculty of Public Administration
University of Ljubljana
SLOVENIA
aleksander.aristovnik@fu.uni-lj.si

Lan Umek
Faculty of Public Administration
University of Ljubljana
SLOVENIA
lan.umek@fu.uni-lj.si

Dejan Ravšelj
Faculty of Public Administration
University of Ljubljana
SLOVENIA
dejan.ravselj@fu.uni-lj.si

CHATGPT AND AI IN K-12 EDUCATION: VIEWS AND PRACTICES OF GREEK TEACHERS

Apostolos Kostas
University of the Aegean, Dept. of Primary Education
GREECE

Christos Chanis
University of the Aegean, Dept. of Primary Education
GREECE

Abstract

The study aims to explore teachers' views and practices on the use of ChatGPT in education, analyzing survey answers from 106 teachers about effectiveness, challenges, and possible opportunities. Findings suggest a moderate level of familiarity with ChatGPT, alongside a high potential for the facilitation of personalized learning. Moreover, concerns regarding data privacy, algorithmic bias, and the necessity for adequate training and support were reported as significant challenges. This research underscores the need for rigorous teacher training as well as the formulation of relevant policies and support towards an effective and ethical use of AI in education.

Introduction

The advent of new AI tools in education encompassing adaptive learning systems, analytical tools, and automation functionalities is about to bring a paradigm shift in the educational sector (Doroudi, 2023). It has unveiled new possibilities and further augmentation is envisioned in the form of innovative AI tools like ChatGPT (GPT: Generative Pre-Trained Transformers), which, when oriented towards content creation and dynamic interactivity, holds immense potential to revolutionize education (Crompton & Burke, 2024). However, AI in education (AIED) is confronted with substantial challenges (Hays et al., 2024). Coupled with the risk of oversimplifying educational processes, the need for an established ethical and regulatory framework in the realm of AI-operated education becomes even more critical (Kim & Adlof, 2024). Hence, it is crucial to address these concerns effectively to ensure the successful implementation of AIED while upholding the necessary ethical standards. Moreover, since 2023 with the advent of Generative AI, there has been an exponential surge in research interest on AIED (Yim & Su, 2024), while a Foresight research project about the use of Generative AI in Greece (National Centre for Social Research (EKKE) & National Centre of Scientific Research "Demokritos" (NCSR "D"), 2023) reported that AI seems to indicate an explosive and perhaps irreversible techno-social initiative with which we must learn to coexist. In this context, this study aims at investigating educators' views and practices regarding the use of ChatGPT in school education, focusing on benefits, challenges and necessary actions for an effective and ethical AIED.

CHATGPT in Education

ChatGPT is a Large Language Model (LLM) leveraging patterns and linguistic structures to comprehend and generate automated text (OpenAI, 2023). Initially trained through a vast data of human dialogues, ChatGPT was released for use online in Nov 2022. It utilizes deep learning techniques for Natural Language Processing (NLP), creation of natural human language (Farrokhnia et al., 2024), and generation of realistic texts as pertinent responses to user queries (prompts) (Ray, 2023). Generative AI applications like ChatGPT have created new possibilities and perspectives in the way humans interact with machines, significantly affecting education (Waltzer et al., 2023). Crompton & Burke (2024) outline the primary applications of ChatGPT as supporting teaching, automating processes, providing ongoing support for students, clarifying complex concepts, fostering dialogic support, assisting in writing tasks, facilitating self-assessment, and augmenting students' engagement. Nevertheless, they highlight reliability, integrity, and data security issues as challenges. Similarly, Kim & Adlof (2024) categorise the potential benefits of ChatGPT in the field of productivity, preparation, and problem-solving, both inside and outside the classroom, for both students and educators, while expressing concerns about academic integrity, the risk of misinformation, and the decrease in critical thinking. Also, in their review van den Berg & du Plessis (2023) mentions lesson plan development, openness, and critical thinking as educational opportunities provided by ChatGPT. Regarding educators' perspectives: Ali et al. (2023) report positive views of ChatGPT as a tool for fostering and enhancing reading and writing skills; Bekeš & Galzina (2023) report low awareness among educators about AI; Monteiro et al. (2024) report that educators believe that ChatGPT will significantly impact the quality of education, particularly in the domain of student assessment; while Galindo-Dominguez et al. (2024) report that despite having a positive attitude towards ChatGPT, only a small percentage incorporate it in their teaching, mainly for content production. From the indicative studies presented above, it becomes evident that there is a high degree of global interest in examining the use of ChatGPT in school education, as well as in identifying views and practices of educators towards AIED. Also, the fact that literature review shows a lack of relative research in Greece is reinforcing the need to further research Greek educators' perceptions concerning AIED.

Research

The study seeks to explore current practices and benefits, barriers and necessary actions for the effective use of ChatGPT by Greek educators with the following research questions:

- RQ1: *What are the teachers' views of and perceived readiness for ChatGPT*?
- RQ2: *What are the teachers' perceived benefits and challenges of using ChatGPT*?
- RQ3: *What are the teachers' perceived necessary actions towards ethical AIED*?

The study follows a quantitative approach based on empirical data gathered via a survey questionnaire, which was constructed based on the corresponding literature review. The questions, aimed at gauging views and current practices of the participants, were structured mainly on a Likert scale (from 1 (lowest) to 5 (highest) response value), composed of 25 questions in total, and were grouped as follows:

- Demographic data [Questions: 1-10]
- Teachers' views and perceived readiness [Questions: 11-16]
- Teachers' perceived benefits and challenges [Questions: 17-18]
- Teachers' perceived necessary actions from the state [Questions: 19-25]

Data was gathered by distributing an online survey through email to school teachers using convenience sampling (Creswell, 2012), making the response collection process quick and effective. Responses were collected using Google Forms and analyzed with IBM SPSS v.26. A total of 106 teachers responded to the survey, mostly females (84.9%), between 22-40 years old (68.9%), with moderate teaching experience (1-6 years) (62.3%), with postgraduate studies (60.38%), certified ICT skills (91.6%) and a balanced level of training in AI tools (Table 1).

Table 1

Demographics and ICT Background of Teachers Responding to Survey

Demographics & Background	Frequencies (N %) (most frequently occurring response is bold-faced)
Gender	M: 15 (14.2%), **F: 90 (84.9%)**, Other: 1 (0.9%)
Age	**22-29: 41 (38.7%)**, 30-35: 20 (18.9%), 36-40: 12 (11.3%), 41-45: 8 (7.5%), 45+: 25 (23.6%)
Teaching experience	**1-3: 44 (41.5%)**, 4-6: 22 (20.8%), 7-11: 11 (10.4%), 12+: 29 (27.4%)

Demographics & Background	Frequencies (N %) (most frequently occurring response is bold-faced)
Studies*	Bachelor: 51 (48.11%), **Master: 64 (60.38%)**, PhD: 5 (4.7%)
Training in AI	Yes: 45 (42.5%), **No: 61 (57.5%)**
ICT skills*	None: 9 (8.4%), **ECDL: 70 (65.4%)**, L1: 11 (10.3%), L2: 15 (14%), Bachelor: 8 (7.5%)

Note: For "Studies" and "ICT skills", respondents could choose more than one answer.

Results

Results are presented according to the research questions, which are related to three parts of the survey tool, as described in the previous section.

RQ1: What are the Teachers' Views of and Perceived Readiness for ChatGPT?

According to Table 2, only 28 participants (26.4%) state that they have used ChatGPT for educational purposes, where 78 participants (73.6%) state that either they do not know ChatGPT, or they have not used it or used it in in their teaching.

Table 2

Teachers' Self Reports of Familiarity with AI and ChatGPT

Response Options	N	%
I know ChatGPT but I have never used it	34	32.1
I know ChatGPT and I have used it, but not in education	32	30.2
I know ChatGPT and I have used it in education	28	26.4
I don't know ChatGPT	12	11.3

Regarding educators' perceived readiness to use Generative AI tools in education on a scale of 1-5, participants' answers revealed low familiarity with ChatGPT (M=2.61, SD=1.21) and high needs for training in using AI tools (M=4.14, SD=0.98) as we can see in Table 3.

Table 3

Teachers' Perceived Readiness to Use AI and ChatGPT

Readiness Questions (1="Totally Disagree", 2="Disagree", 3="Neutral", 4="Agree", 5="Strongly Agree")	**M**	**SD**
I am interested in receiving more training on AI tools	4.14	0.98
I feel ready to incorporate Generative AI in my teaching	2.89	1.25
I am familiar with integrating ChatGPT into my teaching	2.61	1.21

Regarding ChatGPT as a support mechanism for education (Table 4), most of the teachers see the role of ChatGPT as moderately effective in facilitating personalized learning experiences (M=3.08, SD=0.93) and enhancing students' interactivity and commitment (M=3.08, SD=1.03).

Table 4

Teachers' Reported Types of Support using ChatGPT in Teaching and Learning

Types of Support (Support level: 1="None", 2="Small", 3="Moderate", 4="Strong")	**M**	**SD**
Personalized learning	3.08	0.93
Interactive learning and commitment of students	3.08	1.03
Evaluation and feedback	2.87	0.99
Administrative tasks	2.87	1.06
Participation	2.86	1.03

In addition, it was revealed that most teachers use ChatGPT to plan their lessons, create educational resources, conduct their research and proofreading, edit, and improve their written texts, as Table 5 demonstrates.

Table 5

Teachers' Perceived Educational Affordances of ChatGPT

Types of Educational Affordances	**N**	**%**
Design lesson plan and curriculum	22	50.00
Research	17	38.60
Edit written text	17	38.60

Types of Educational Affordances	**N**	**%**
Create educational content	17	38.60
"Live" use during teaching	12	27.30
Evaluation, feedback and comments	9	20.50
Administrative tasks	9	20.50
Programming	5	11.40

RQ2: What are Teachers' Perceived Benefits and Challenges of Using ChatGPT?

Most of the teachers reported that they saved time using ChatGPT (N=53, 50%) and that teaching was more creative (N=48, 45.28%). Also, most of the teachers reported that using ChatGPT was helpful for students with special needs (N=39, 36.79%), provided faster feedback to students (N=34, N=32.08%), and better student engagement due to educational material of better quality generated from ChatGPT (Table 6).

Table 6

Teachers' Perceived Benefits of ChatGPT in Education

Perceived Benefit	**N**	**%**
Time saved in lesson preparation	53	50.00%
More creative teaching	48	45.28%
More help for students with learning or other difficulties	39	36.79%
Faster feedback to students	34	32.08%
Greater student engagement	32	30.19%
Higher quality of educational materials	27	25.47%
Higher level of personalized teaching and learning	26	24.53%

Finally, Table 7 shows that the three main concerns related to the use of ChatGPT are limitations in literacy skills such as writing (N=76, 71.70%), and critical thinking (N= 69, 65.09%) and increase of legal issues such as intellectual property and data protection (N=65, 42.45%). Also, increased dependency from AI tools was reported as a major challenge from the participants (N=64, 60.38%), as well as limited quality and reliability of content produced from Generative AI tools (N=58, 54.70%) and limited human control of AI (N=47, 44.34%).

Table 7

Teachers' Perceived Challenges of ChatGPT in Education

Perceived Challenge	**N**	**%**
Limit writing and information literacy of the students	76	71.70%
Limit critical thinking	69	65.09%
Increase intellectual property and data protection issues	65	61.30%
Increase dependency from AI tools	64	60.38%
Limited quality and reliability of content	58	54.70%
Limit human control over content produced from AI	47	44.34%
Increase plagiarism	47	44.34%
Limit students' cognitive abilities	45	42.45%
Limit academic integrity	37	34.91%
Increase dependency from private companies	36	33.96%
Limit teacher's role	35	33.02%
Increase digital divide in education	25	23.58%

RQ3: What are Teachers' Perceived Necessary Actions towards a Proper and Ethical AIED?

As can be seen from Table 8, according to the perceptions of the Greek teachers, the top 3 priority actions from the state should do are: a) ensure that data privacy and security measures are strictly adhered to in educational AI applications (M=4.66, SD=0.64), b) formulate policies to guide the ethical use of AI in education (M=4.44, SD=0.78) and c) invest in technological infrastructure to ensure equal access to artificial resources intelligence in education in different regions and communities (M=4.29, SD=0.95).

Table 8

Teachers' Attitudes towards Proper and Ethical AIED

The state should… (1="Totally Disagree", 2="Disagree", 3="Neutral", 4="Agree", 5="Strongly Agree")	**M**	**SD**
ensure that data privacy and security measures are strictly adhered to in educational AI applications	4.66	0.64

The state should… (1="Totally Disagree", 2="Disagree", 3="Neutral", 4="Agree", 5="Strongly Agree")	**M**	**SD**
formulate policies to guide the ethical use of AI in education	4.44	0.78
invest in technological infrastructure to ensure equitable access to AI resources in various regions and communities	4.29	0.95
be involved in setting standards and guidelines for integrating AI into educational programs	4.17	0.90
promote and support research and innovation in AI for educational purposes	4.16	0.99
play a significant role in providing training to educators on AI technologies	4.14	0.99
allocate funds and resources to support the integration of AI technologies in educational institutions	4.07	1.05

Finally, regarding teachers' professional development on AI Literacy, Table 9 presents the thematic topics that teachers perceived as the most important and that training programs should contain: data privacy and security (M=4.47, SD=0.71), and technical aspects of using AI tools (such as operation, troubleshooting, updates) (M=4.40, SD=0.80).

Table 9

Dimensions of Teachers' Professional Development on AI

Importance of Different Types of Professional Development (1="Totally Disagree", 2="Disagree", 3="Neutral", 4="Agree", 5="Strongly Agree")	**M**	**SD**
Training on data privacy and security is necessary in the context of AI applications in education	4.47	0.71
Training on the technical aspects of using AI tools (such as operation, troubleshooting, updates) is important	4.40	0.80
Understanding the ethical implications and responsible use of AI in the classroom is an essential part of educator training	4.35	0.71
Educator training should include strategies for effectively integrating AI tools into lesson planning and delivery	4.34	0.71
Educators should be trained in adapting pedagogical methods to effectively integrate AI technologies into their teaching	4.30	0.76
It is important that training covers the limitations and potential biases inherent in AI technologies	4.29	0.76

Discussion and Conclusions

This study presents results from a survey in Greece about primary school teachers' perceptions of various aspects of ChatGPT use in education. Teachers rated ChatGPT and AI tools in general as somewhat effective in personalizing learning experiences and better engaging students, while improving administrative effectiveness. Teachers are also concerned about the privacy of data and showed concerns with algorithmic biases, recommending that strict ethical guidelines and security measures be put in place in the implementation of AI in education. Most of the teachers were clueless about the practical application of ChatGPT, which also reflects general uncertainty about integrating AI tools and teaching practices. This research clearly expresses the pressing need for comprehensive training programs for upgrading the technical skills and the level of awareness of teachers about the pedagogical implications of AI. The role of the state in AI integration emerged as crucial since the majority of teachers strongly agreed that the government should be responsible for ensuring data privacy, developing ethical guidelines, investing in technological infrastructure, and supporting AI research and training for education. This indicates the necessity of proactive policy formulation to ensure equitable access to AI resources and education innovations. These teacher-training programs should look at AI not only from a technical point of view but also from pedagogical adaptations, some of its possible ethical implications, data privacy, and avoidance of biases. The teachers indicated they needed to understand how to incorporate effectively the AI tools in the planning and delivery of their lessons.

While the adoption of AI by the teachers was relatively low, participants who used AI reported improvements in terms of preparing lessons and curriculum development. Inadequate training, organizational support, and the lack of familiarity with AI tools were reported as challenges that need immediate attention in teacher training and resource provisioning. Opportunities lay in this ability to offer better teaching materials and improved ways of assessing, as well as efficiency to an improved level, hinting at the potential transformation in practices that AI could bring to education. While this potential puts AI in the forefront of changing educational practice, rapid developments in AI and tool-specific concerns with, for example, ChatGPT, dictate the need for research and continuous updating of teacher training curricula to keep abreast of technological development. Other concerns over AI emanated from the possible decline in some essential academic skills because students over-relied on technology. This implied that the balance between the integration of AI had to be reached by supporting skill development but not taking away critical thinking or problem solving. Future predictions for AI in education are an expanded role for AI in teacher training, access to tools, and community education, underlining AI's transformation potential in reshaping educational landscapes.

Study limitations include the diminished generalizability of this study because of the specific sample and educational context—limitations imposed by the quantitative data, which do not capture the entire spectrum of teacher experiences and attitudes, and the fast-changing field of AI, where findings may soon become outdated. Future research should also look to mixed methods, deepen understanding, and assure that technological progress continues to update findings. In conclusion, whilst AI possesses significant potential to improve educational practice, there are substantial obstacles to overcome. These challenges include providing adequate training, developing robust policy frameworks, and securing ongoing support from educational institutions and the state. Addressing these challenges effectively is crucial for harnessing the potential advantages that AI could provide to education.

References

Ali, J. K. M., Shamsan, M., A. A., Hezam, T. A., & Mohammed A. A. Q. (2023). Impact of ChatGPT on learning motivation: Teachers and students' voices. *Journal of English Studies in Arabia Felix*, *2*(1), 41-49. https://doi.org/10.56540/jesaf.v2i1.51

Bekeš, E. R., & Galzina, V. (2023). Exploring the pedagogical use of AI-powered chatbots educational perceptions and practices. *46th MIPRO ICT and Electronics Convention (MIPRO)*, 636–641. https://doi.org/10.23919/MIPRO57284.2023.10159734

Creswell, J. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research (4th ed.)*. Pearson.

Crompton, H., & Burke, D. (2024). The educational affordances and challenges of ChatGPT: State of the field. *TechTrends 68*, 380–392. https://doi.org/10.1007/s11528-024-00939-0

Doroudi, S. (2023). The intertwined histories of Artificial Intelligence and education. *International Journal of Artificial Intelligence in Education*, *33*, 885–928. https://doi.org/10.1007/s40593-022-00313-2

National Centre for Social Research (EKKE) & National Centre of Scientific Research “Demokritos” (NCSR “D”). (2023). *Generative AI Greece 2030: Possible futures of Generative Artificial Intelligence* in Greece. Athens: Special Secretariat of Foresight. https://foresight.gov.gr/wp-content/uploads/2024/04/Gen_AI_Greece_EN_s.pdf

Farrokhnia, M., Banihashem, S. K., Noroozi, O., & Wals, A. (2024). A SWOT analysis of ChatGPT: Implications for educational practice and research. *Innovations in Education and Teaching International*, *61*(3), 460–474. https://doi.org/10.1080/14703297.2023.2195846

Galindo-Domínguez, H., Delgado, N., Losada, D. & Etxabe, J-M. (2024). An analysis of the use of artificial intelligence in education in Spain: The in-service teacher's perspective. *Journal of Digital Learning in Teacher Education*, *40*(1), 41-56. https://doi.org/10.1080/21532974.2023.2284726

Hays, L., Jurkowski, O. & Sims, S.K. (2024). ChatGPT in K-12 Education. *TechTrends*, 68, 281–294. https://doi.org/10.1007/s11528-023-00924-z

Kim, M., & Adlof, L. (2024). Adapting to the future: ChatGPT as a means for supporting constructivist learning environments. *TechTrends, 68*, 37–46. https://doi.org/10.1007/s11528-023-00899-x

Monteiro F.F., Souza P.V.S., da Silva, M.C., Maia, J.R., da Silva, W.F. & Girardi D. (2024). ChatGPT in Brazilian K-12 science education. *Frontiers in Education*, *9*, 1321547. https://doi.org/10.3389/feduc.2024.1321547

OpenAI (2023). *Introducing ChatGPT*. https://openai.com/blog/chatgpt

Ray, P. P. (2023). CHATGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. *Internet of Things and Cyber-Physical Systems*, *3*, 121–154. https://doi.org/10.1016/j.iotcps.2023.04.003

Waltzer, T., Cox, R. L., & Heyman, G. D. (2023). Testing the ability of teachers and students to differentiate between essays generated by CHATGPT and high school students. *Human Behavior and Emerging Technologies*, *1*, 1–9. https://doi.org/10.1155/2023/1923981

van den Berg, G. & du Plessis, E. (2023). ChatGPT and Generative AI: Possibilities for its contribution to lesson planning, critical thinking and openness in teacher education. *Educational Sciences*, *13*(10), (998). https://doi.org/10.3390/educsci13100998

Yim, I.H.Y., & Su, J. (2024). Artificial intelligence (AI) learning tools in K-12 education: A scoping review. *Journal of Computers in Education*. https://doi.org/10.1007/s40692-023-00304-9

Author Details

Apostolos Kostas,
Dept. of Primary Education, University of the Aegean
GREECE
apkostas@aegean.gr

Christos Chanis,
Dept. of Primary Education, University of the Aegean
GREECE
premnt22039@rhodes.aegean.gr

NEWSPIRACY—TRAINING TEACHERS IN POST TRUTH RECOGNITION

Mariano Sanz-Prieto
Elena López-de-Arana
Gema de-Pablo-González
Universidad Autónoma de Madrid
SPAIN

Abstract

The pervasiveness of information overload, or "infoxication", renders us increasingly susceptible to fake news and its uncritical acceptance. This phenomenon, characterized by deliberate disinformation, has found fertile ground in the political sphere. Consequently, fostering critical thinking and proper education in our students is crucial for solidifying our democracy on robust foundations.

Newspiracy emerges as a project offering valuable tools and training to empower educators in addressing these issues with their students. This initiative seeks to equip them with the necessary skills to navigate the complex landscape of information and discern genuine news from fabricated narratives. By nurturing critical thinking and media literacy, we can empower individuals to make informed decisions, combat misinformation, and ultimately safeguard the integrity of our democratic processes.

Introduction

In contemporary society, we navigate a digital landscape saturated with various channels for creating, sending, accessing, and receiving information. These include traditional media outlets, their online platforms, social networks, instant messaging applications, and email, among others. While this diversity facilitates access to a wealth of information, it also poses the risk of information overload, commonly referred to as "information intoxication" (infoxication), a concept already discussed in the 1990s (Arribas & Sanz-Prieto, 1996). The phenomenon has since become more "professionalized". Essentially, infoxication consists of an overload of information that exceeds an individual's processing capacity. In our current context, this information often reaches us passively via social networks and instant messaging, without us always having control over it. This scenario presents a new challenge: discerning between valuable, biased, or false information, which complicates its processing into useful knowledge. Responsible management of this information overload has thus become a critical skill in the digital era.

The term "fake news" refers to lies, hoaxes, misleading or false news (Martín-Herera & Micaletto-Belda, 2021). In essence, it involves the intentional dissemination of false or misleading information to manipulate public opinion or create confusion. However, for our specific analysis, we will primarily utilize the definition provided by Baptista et al. (2021), which characterizes fake news as an article that fabricates a report or real news in the online domain, mimicking its format to appear legitimate and credible to the public.

This phenomenon is not new but has seen a significant surge with the expansion of digital technologies, particularly social networks and instant messaging applications. The speed at which fake news spreads is exponentially greater than that of verified information. This rise in disinformation results in widespread uncertainty regarding the information available online, making it one of the most pressing and concerning issues today (Alonso García et al., 2020). Additionally, the influence power of fake news is substantial, due to its capacity to generate intense emotions and appeal to cognitive biases. It can have negative impacts in various spheres, especially in the political and social realms, where it can sway public opinion, manipulate electoral processes, and promote hate and discrimination. Most alarmingly, it can erode trust in institutions.

Post-truth Society

Has truth ever existed, or does it exist today? Generally, our perspective will limit what we can perceive or believe. Morin (1999) asserted that knowledge is not a reflection of reality but a translation or interpretation we make, where language and thought mediate, as well as subjectivity and affectivity. It is naïve to think that rationality dominates emotion. The term "post-truth" refers to the phenomenon where, in today's digital society, objective facts are less significant or effective in shaping public opinion. In many cases, opinions are given the same value, and appeals to emotion or personal beliefs—whether false or not—end up holding the same weight as objective facts or data. The era of post-truth signifies a shift in the credibility we grant to information. The necessity to substantiate what is said becomes blurred, and discourses are accepted or rejected based on how well they align with pre-existing mental schemas (Martín-Herera & Micaletto-Belda, 2021).

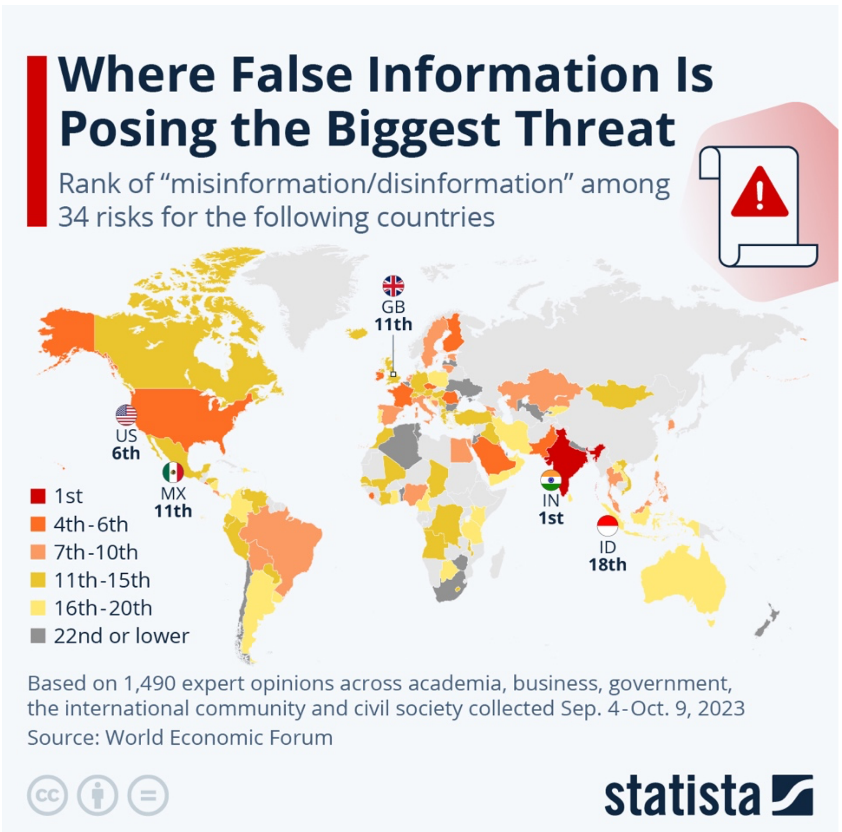
The culture of post-truth is often justified under the guise of freedom of expression. However, the reality is that it erodes democracy through the disinformation and propaganda to which citizens are subjected by fake news. It directly impacts the ability to access reliable and valid information. We must begin to consider how to resolve the conflict between two democratic rights: freedom of expression versus access to truthful information. To address this, we need to analyze the methods used to corrupt the system.

Where Are We Now?

The reality is that social networks and the increasing digitalization of our lives have enhanced the public's ability to exercise the right to freedom of expression. This should ideally translate into greater opportunities to contrast opinions and enable the closest approximate to the truth to emerge. However, the reality is that fake news often produces the opposite effect, using freedom of expression to undermine the truth by slandering and increasing hostility and hatred towards socially vulnerable groups such as immigrants or the diversity of affective-sexual relationships. It also directly stigmatizes feminism, which means half of our population (Gómez de Ágreda, 2018).

Figure 1

Threat with False Information in the World. Statista



Note. From Fleck, 2024, https://www.statista.com/chart/31605/rank-of-misinformation-disinformation-among-selected-countries/

In the current digital era, information spreads at unprecedented speeds, and the same applies to fake news. These news pieces, characterized by deliberate disinformation circulated across various media, have found fertile ground in the political sphere (Baptista & Gradim, 2022). Certain political parties have utilized and continue to use them as a strategic tool to influence public opinion and advance their agendas (Igwebuike & Chimuanya, 2020). According to Baptista and Gradim (2020), this strategy not only manipulates the perception of facts but also has devastating consequences for already vulnerable groups such as women, the LGTBIQ+ community, and refugees or migrants.

We aim to explore how fake news created and propagated by far-right parties affects these oppressed groups and perpetuates inequality and discrimination in society. Recognizing such fake news as a society is crucial since, as noted by Lawson et al. (2023), fake news can foster political polarization, provoke division among groups, and encourage malicious behaviours.

In this context, far-right parties have found an opportunity to reinforce their ideological narratives and exacerbate polarization (Leyva & Beckett, 2020). By employing precise and targeted communication strategies, these political formations create and disseminate false content which, when shared massively, manage to sow informational chaos and confusion among the public (Peucker & Fisher, 2022). This confusion translates into widespread distrust of traditional media and democratic institutions, facilitating the advance of authoritarian and anti-democratic agendas (Lawson et al., 2023).

Women have historically been one of the groups most affected by fake news. They have been subjected to disinformation campaigns that trivialize or deny gender violence, promote harmful stereotypes, and obstruct efforts to achieve gender equality. Far-right parties often propagate narratives that reinforce traditional gender roles and undermine advancements in gender equality (Almenar et al., 2021). A clear example is the dissemination of false news that exaggerates cases of false gender violence accusations to discredit the feminist movement and policies protecting women (Sahadevan & Deepak, 2022). These news pieces not only undermine the credibility of gender violence victims but also foster a climate of distrust and hostility towards women who report abuse. They perpetuate the notion that advancements in women's rights threaten social stability, which can have a deterrent effect on the fight for gender equality (Geertsema-Sligh & Vos, 2022).

Refugees and migrants are another group that has suffered the consequences of fake news propagated by far-right parties. These news items often depict migrants as criminals, terrorists, or economic parasites burdening public resources and posing national security threats (Wright et al., 2020). This disinformation is used to justify restrictive immigration policies and draconian security measures (Boukala, 2021).

The widespread dissemination of these fake news creates an environment of xenophobia and racism that exacerbates the marginalization of migrants and refugees. They are denied access to basic opportunities and resources and are exposed to violence and harassment. Furthermore, this fake news can sway public opinion to support policies that violate the human rights of migrants and refugees (Amores et al., 2020).

The LGTBIQ+ community is also gravely affected by fake news propagated by far-right parties. These news stories often spread myths and falsehoods about LGTBIQ+ individuals, portraying them as a threat to morality and social order (Peucker & Fisher, 2022). Recurrent examples include the propagation of conspiracy theories linking the LGTBIQ+ community to child abuse or the so-called "gender ideology"' a fictitious construct purportedly aiming to impose a radical agenda on society (Leyva & Beckett, 2020). These examples of fake news not only reinforce existing prejudices and discrimination but also incite violence and hatred against LGTBIQ+ individuals. The demonization of this community in the media can legitimize aggressive behaviours and justify the denial of their fundamental rights. Ultimately, these false narratives hinder the fight for equality and the acceptance of sexual and gender diversity (Hinz et al., 2023).

Far-right parties effectively utilize social networks to spread fake news, and platforms such as Facebook, TikTok, X (formerly Twitter), and WhatsApp are powerful tools for disseminating false information due to their algorithms prioritizing emotionally charged content (Vziatysheva, 2020). These parties often collaborate with sympathetic media outlets and influential public figures to amplify their messages. The use of bots and trolls is also common, as they can generate an appearance of consensus and massive support for the false narratives (Dourado, 2023).

Fake news propagated by far-right parties affects society at large, not just vulnerable groups. When the populace cannot distinguish between truth and lies, the very foundations of democracy are undermined (Watts et al., 2021). It is crucial to note that young people are particularly vulnerable to the influence of fake news due to their higher exposure to social networks and instant messaging platforms.

In this context, initiatives like Newspiracy become relevant by offering tools and training to detect and combat fake news. The project aims to strengthen social resilience against manipulation and disinformation through the promotion of critical thinking and the development of skills to evaluate information. Specifically targeting future educators ensures that these skills are instilled in future generations from the school level.

NEWSpiracy: Fighting the Online Post-truth Conspiracy

The Newspiracy project (European Commission, 2022) commenced in 2022 as a response to the information overload arising from new digital media and the advent of social networks, which have contributed to the rise of fake news. The objective of Newspiracy is to raise public awareness about the existence and influence of fake news, understanding its mechanisms and creation processes to enable better detection and deeper analysis.

Additionally, the project addresses topics related to the appropriate use of media, types of fake news, and potential solutions to this phenomenon, with a particular emphasis on the development of critical thinking as the primary driver of change. NEWSpiracy's main goal is to develop critical thinking skills among university professors and students from various undergraduate and graduate programs, emphasizing that they must be critical of the information they receive, as they are the ones who will shape the society of the future. To develop critical thinking skills, the project focuses on fake news. To this end, an online training and an interactive environment have been developed to address these issues.

The specific objectives of this project are:

- To develop critical thinking about fake news among university students.
- To raise awareness of the realities faced by the most vulnerable sectors of society and the negative impact fake news has on them.
- To detect and analyze fake news.
- To explore possible solutions to the phenomenon of fake news.

The project began in November 2022 and is scheduled to conclude in October 2024, lasting a total of two years. The project consortium comprises five countries and six partners:

- Autonomous University of Madrid (Spain) - Coordinator
- University of the Aegean (Greece)
- Latvian University (Latvia)
- CARDET (Cyprus)
- PRO WORK (Netherlands)
- Fundación SIGLO22 (Spain)

The project's main outcomes are found in Work Packages 2 and 3: In-service training and Truth-track (a fake news detector and interactive environment).

In-service Training

The in-service training is a learning package aimed at developing critical thinking and identifying fake news through various learning modules:

- Disinformation: fake news and post-truth
- The media: good use of social media
- News items: writing structure

- Critical thinking for active participation in society
- Ways of acting against fake news

These learning modules have been developed in various formats to meet the accessibility needs of our diverse society. Firstly, a downloadable document has been created, accessible from the project platform and website. This document is designed as a "teacher's manual" and can be read virtually in Flipbook format or downloaded as a PDF (https://newspiracy.eu/tutor-handbook/).

Secondly, using instructional design, the learning modules have been made available on a Learning Management System (LMS) platform built with Moodle (https://learning.newspiracy.eu/). This platform is open and accessible to anyone interested. The modules are structured in a way that allows participants to test their knowledge through games, quizzes, and other types of activities.

Additionally, completion badges have been included. As participants complete the modules and their activities, they will earn badges certifying their participation. The platform and modules are accessible in all the languages of the project partners, which include Spanish, Greek, Dutch, and Latvian.

Truth - Track

Truth-Track is an output in an interactive environment (https://newspiracy.eu/truth-track/) that allows participants to generate and comment on news items and posts. With various easy-to-use formats and functionalities, this space fosters transnational cooperation, enhances linguistic diversity, and promotes meaningful interactions between students and faculty. It operates like a social network: users create an account, publish content, and vote or comment on others' posts. The philosophy behind this interactive environment is to apply the knowledge acquired from the training plan of the previous output, learning to identify fake news based on its structure and content. Participants can choose different formats such as a newspaper article, an Instagram post, or a tweet.

Figure 2

Four Truth-Track Interface Examples

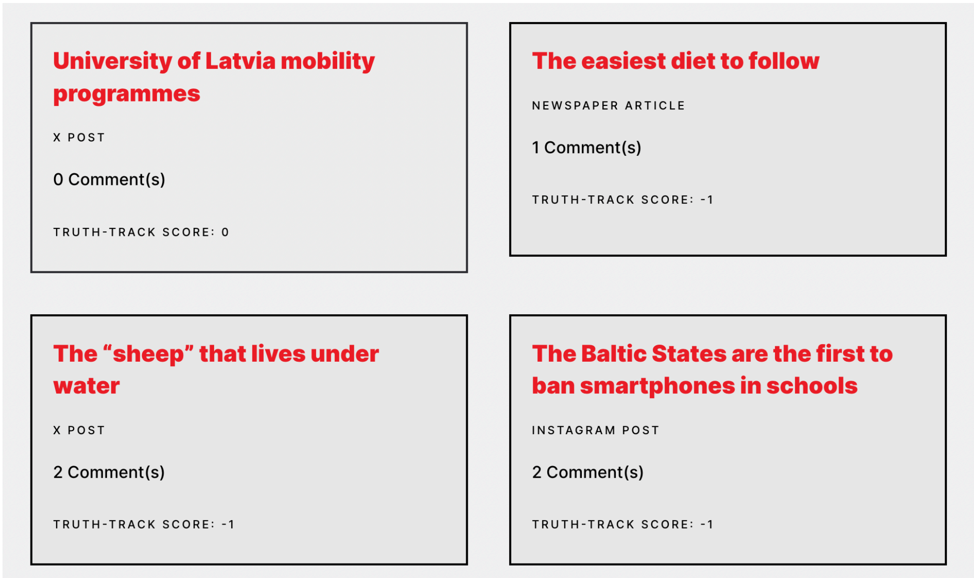
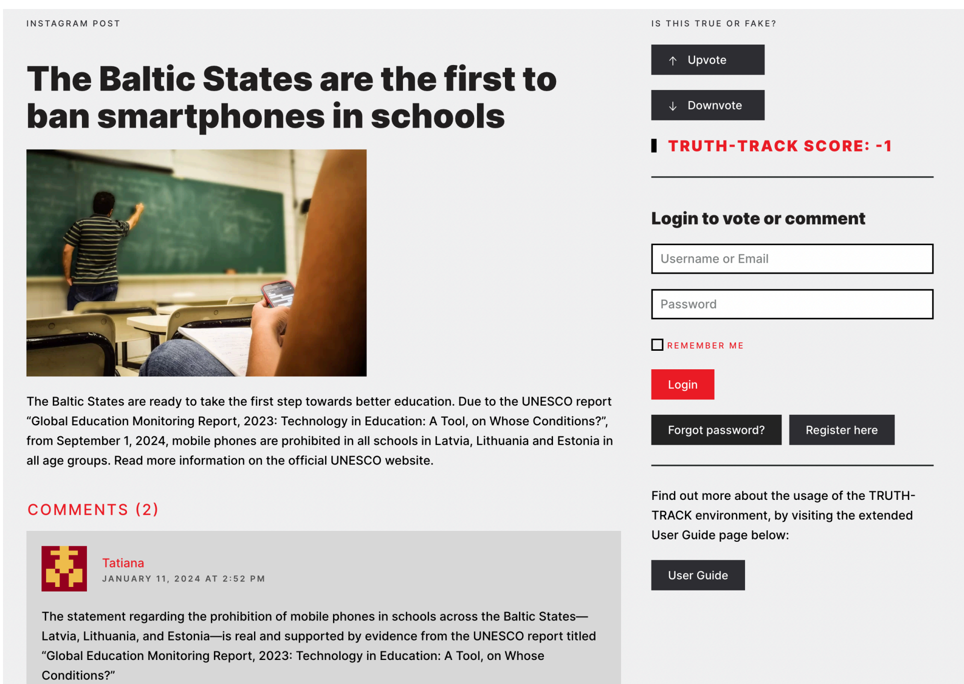


Figure 3

Truth-Truck Interface Example including a Response Comment



Interaction can occur in two ways: voting or commenting. Voting positively indicates that the user considers the post to be real news, while voting negatively indicates it is considered fake news. Each post displays a counter showing how many positive and negative votes it has received, thus revealing whether people believe the news is real or fake. Users can also add comments explaining their opinions.

The project's tools can be used diversely in classrooms, ranging from early childhood education to university levels, adapting specific activities to the age of the students. In some cases, students can directly use the project's platforms, while in others, teachers can generate analysis and interpretation activities based on pre-generated content (López-de-Arana et al, 2024).

Conclusions

Fake news has profound and varied effects on our daily lives, eroding trust in democratic institutions, fuelling political polarisation, and perpetuating discrimination and negative stereotypes towards vulnerable groups such as women, migrants, and the LGTBIQ+ community. Fake news hampers the ability of citizens to distinguish between truth and lies, a fundamental aspect of a healthy functioning democracy. Specifically the analysis of the relationship between the veracity of news and gender is not exhaustive but is consistent, firmly suggesting that gender should be an important consideration in critical studies and scientific research on fake news (Sahadevan & Deepak, 2022). Fake news represents a crucial challenge in the digital age. Addressing this issue requires a collective effort involving educational institutions, media outlets, digital platforms, and the citizenry itself.

Fake news perpetuates discrimination, fosters hatred, and undermines progress towards equality and social justice. Combating this threat requires a coordinated societal effort, including media and digital platforms, to protect the truth and promote a coexistence based on respect and inclusion. Only through education, transparency, and collective responsibility can we mitigate the damage caused by fake news and build a more just, informed, and resilient (digital) society against the threat of disinformation.

This is why it is essential to promote critical education from an early age. Projects such as Newspiracy play a crucial role in developing critical thinking skills among students and teachers. Raising awareness of the existence and impact of fake news, as well as teaching techniques for detecting and analysing fake news, are important steps in this direction. The use of interactive platforms and educational modules accessible in several languages also facilitates this learning.

We must encourage the abandonment of deterministic conceptualizations such as the absolute falsehood promoted by the culture of post-truth, and embrace the complexity of reality and the human condition, learning to "navigate in an ocean of uncertainties through archipelagos of certainty" (López-de-Arana et al., 2013; Morin, 1999, p. 43).

To curb the use of fake news by the far right, it is essential to improve transparency and accountability on social media platforms by developing algorithms that prioritise truthfulness over emotionally charged content. In addition, it is vital to foster international cooperation to regulate and sanction disinformation. Only through a coordinated and multifaceted effort can we reduce the negative impact of fake news and promote a fairer, more informed and cohesive society.

References

Almenar, E., Aran-Ramspott, S., Suau, J., & Masip, P. (2021). Gender differences in tackling fake news: Different degrees of concern, but same problems. *Media and Communication, 9*(1), 229-238. https://doi.org/10.17645/mac.v9i1.3523

Alonso García, S., Gómez García, G., Sanz Prieto, M., Moreno Guerrero, A. J., & Rodríguez Jiménez, C. (2020). The impact of term fake news on the scientific community. Scientific performance and mapping in web of science. *Social Sciences, 9*(5), 73. https://doi.org/10.3390/socsci9050073

Amores, J., Arcila-Calderón, C., & Blanco-Herrero, D. (2020). Evolution of negative visual frames of immigrants and refugees in the main media of Southern Europe. *El profesional de la información.* *https://doi.org/10.3145/epi.2020.nov.24*

Arribas, Y., & Sanz-Prieto, M. (1996). National Profiles: Spain. In *The Multimedia Yearbook 1996*. FPL.

Baptista, J., Correia, E., Gradim, A., & Piñeiro-Naval, V. (2021). The influence of political ideology on fake news belief: The Portuguese case. *Publications, 9*(2), 23. https://doi.org/10.3390/publications9020023

Baptista, J., & Gradim, A. (2020). Online disinformation on Facebook: The spread of fake news during the Portuguese 2019 election. *Journal of Contemporary European Studies*, *30*(2), 297 - 312. https://doi.org/10.1080/14782804.2020.1843415.

Baptista, J., y Gradim, A. (2022). Who Believes in Fake News? Identification of Political (A)Symmetries. *Social Sciences.* *doi:*10.3390/socsci11100460

Boukala, S. (2021). Far-right discourse as legitimacy? Analysing political rhetoric on the “migration issue” in Greece. *Studies in Communication Sciences, 21*(2), 329-341. https://doi.org/10.24434/j.scoms.2021.02.014

Dourado, T. (2023). Who posts fake news? Authentic and inauthentic spreaders of fabricated news on Facebook and Twitter. *Journalism Practice*, *17*(10), 2103 - 2122. https://doi.org/10.1080/17512786.2023.2176352

European Commission. (2022). *Newspiracy: Fighting the online post-truth conspiracy*. ERASMUS Project Number: 2022-1-ES01-KA220-HED-000089608. https://newspiracy.eu/

Fleck, A. (2024, January 19). Where False Information Is Posing the Biggest Threat [Digital image]. Retrieved June 17, 2024, from https://www.statista.com/chart/31605/rank-of-misinformation-disinformation-among-selected-countries/

Geertsema-Sligh, M., & Vos, T. (2022). Running up Against a Brick Wall: U.S. Metajournalistic Discourse of Gender Equality in Newsrooms. *Journalism Studies*, *23*, 1758 - 1778. https://doi.org/10.1080/1461670X.2022.2112905

Gómez de Ágreda, A. (2018). Falsas noticias, no noticias falsas. *Telos, 109*, 18-21. https://telos.fundaciontelefonica.com/wp-content/uploads/2018/10/telos-109-asuntos-de-comunicacion-angel-gomez-de-agreda.pdf

Hinz, T., Walzenbach, S., Laufer, J., & Weeber, F. (2023). Media coverage, fake news, and the diffusion of xenophobic violence: A fine-grained county-level analysis of the geographic and temporal patterns of arson attacks during the German refugee crisis 2015–2017. *PLOS ONE*, *18*(7). https://doi.org/10.1371/journal.pone.0288645

Igwebuike, E. E., & Chimuanya, L. (2020). Legitimating falsehood in social media: A discourse analysis of political fake news. *Discourse and Communication*, *15*(1), 42-58. https://doi.org/10.1177/1750481320961659

Lawson, M. A., Anand, S., & Kakkar, H. (2023). Tribalism and tribulations: The social costs of not sharing fake news. *Journal of Experimental Psychology: General, 152*(3), 611-631. https://doi.org/10.1037/xge0001374

Leyva, R., & Beckett, C. (2020). Testing and unpacking the effects of digital fake news: on presidential candidate evaluations and voter support. *AI & SOCIETY*, *35*, 969 - 980. https://doi.org/10.1007/s00146-020-00980-6

López-de-Arana, E., Rekondo, Z. & Salegi, E. (2013). Ziurgabeak diren testuinguruen erabilera Haur Hezkuntza Graduko ikasleen formazioan. *Ikastaria. 19*, 285-310.

López-de-Arana, E., Sanz-Prieto, M., & de Pablo González, G. (2024). Propuestas pedagógicas para ayudar a la infancia y adolescencia a descubrir la verdad sobre las fake news. In A. Neubauer (Ed.), *La educación intercultural en la sociedad digital: teoría y propuestas innovadoras* (pp. 81-97). Editorial Universitas, S.L.

Martín-Herrera, I., & Micaletto-Belda, J. P. (2021). Opiniones y actitudes de los estudiantes universitarios de Comunicación ante las fake news. Diagnóstico en un ecosistema docente. *Comunicación y Hombre, 17*, 193-206. doi: https://doi.org/10.32466/eufv-cyh.2021.17.661.193-206

Morín, E. (1999). *Descargar los 7 saberes necesarios para la educación del futuro*. United Nations Educational, Scientific, and Cultural Organization (UNESCO). https://www.edgarmorinmultiversidad.org/index.php/descarga-libro-los-7-saberes.html

Peucker, M., & Fisher, T. J. (2022). Mainstream media use for far-right mobilisation on the alt-tech online platform Gab. *Media, Culture & Society*, *45*(2), 354 - 372. https://doi.org/10.1177/01634437221111943

Sahadevan, N., & Deepak, P. (2022). Gender bias in fake news: An analysis. *ArXiv*:2209.11984 [csCY]. https://doi.org/10.48550/arXiv.2209.11984

Vziatysheva, V. (2020). How fake news spreads online? *International Journal of Media and Information Literacy*. https://doi.org/10.13187/ijmil.2020.2.217

Watts, D., Rothschild, D., & Mobius, M. (2021). *Measuring the news and its impact on democracy.* In D. A. Scheufele (Ed.), *Proceedings of the National Academy of Sciences 118*(15): *Advancing the Science and Practice of Science Communication: Misinformation about Science in the public sphere*. *https://doi.org/10.1073/pnas.1912443118*

Wright, C., Brinklow-Vaughn, R., Johannes, K., & Rodriguez, F. (2020). Media portrayals of immigration and refugees in hard and fake news and their impact on consumer attitudes. *Howard Journal of Communications*, *32*(4), 331 - 351. https://doi.org/10.1080/10646175.2020.1810180.

Author Details

Mariano Sanz-Prieto
Universidad Autónoma de Madrid
Spain
mariano.sanz@uam.es

Elena López-de-Arana
Universidad Autónoma de Madrid
Spain
elena.lopezdearana@uam.es

Gema de-Pablo-González
Universidad Autónoma de Madrid
Spain
gema.depablo@uam.es