

PREFACE

Smart Learning Ecosystems as engines of the twin transitions

This Special Issue contains contributions from researchers and practitioners involved in developing Smart Learning Ecosystems and Smart Digital Services as engines of the twin transitions. The need for innovative and sustainable educational solutions has become paramount, concurrent with changing our lifestyles and making them more sustainable, as the world faces new challenges, including pandemics, wars, climate change, and socio-economic inequalities. The SDGs [1] and the fostered cultural and technological transitions (e.g., green transition) have become new challenges with which smart learning ecosystems and communities must measure themselves to support the education of competent and responsible future citizens. As such, the development of Smart Learning Ecosystems leveraging advanced digital technologies aims to create adaptive, inclusive, and resilient learning environments that respond to the needs of both individuals and communities.

The achievement of an adequate level of smartness in the learning ecosystems is, however, a process that needs a long-term vision, multidisciplinary competencies, an attitude to understand people and contexts and to mediate points of view, a dynamic approach to resilience to keep on track and achieve, step-by-step, the foreseen goals: in short, an attitude to design and implement sustainable projects and processes aimed at achieving people-centred smart environments and education.

Concurrently with the initially mentioned challenges, we also observe the amplifying power of digital technologies, which could contribute, through educational processes, to the development of a fairer and more equitable society and, at the same time, to more careful use of resources [2]; but, on the other hand, if not adequately utilised, digital technologies could also lead to a deepening of existing gaps. Thus, we have to face a parallel digital transition that raises many questions about its impact on humans and the environment, including its energy sustainability.

The selected papers in this Special Issue explore various dimensions of Smart Learning Ecosystems and Smart Digital Services while providing valuable insights into their implementation, challenges, and impact. These studies provide a comprehensive overview of the current landscape and future directions while covering innovative city learning frameworks, emotion recognition in educational settings, the influence of coloured lighting on student affective processes, co-designing digital ecosystems for children with disabilities, advanced natural language processing in digital libraries, and various gamified learning experiences. The collection of papers from this Special Issue contributes to a deeper understanding of how technology can be harnessed to create smarter and more sustainable educational environments.

The article titled “Key elements, processes and research gaps in city learning as an innovation ecosystem: A scoping review” by Pradipta Banerjee and Sobah Abbas Petersen [3] conducts a scoping review of relevant literature and a qualitative analysis of key characteristics of the existing frameworks for city transformations that support learning and enhance innovation, with an emphasis on twin transitions of the city and lifelong learning. The study explored 11 databases, and out of the 2139 initially retrieved articles, 14 were considered for the final analysis. The study identified the main concepts, key elements, and processes in city learning, including their mapping to design more adequate solutions. Moreover, the study introduced current research gaps, emphasising the lack of frameworks that address how a city as a system could learn, concurrently marking a lack of systematically motivating citizens to participate and engage in city activities.

The article titled “*The school as a place learning ecosystem - Participatory evaluation of the boundary conditions: the case of the IIS Amaldi*” by Carlo Giovannella and Maria Rosaria Autiero [4] investigates the potential of using the community pact to cultivate learning ecosystems within school communities, via the case study of IIS Amaldi. The paper explored the boundary conditions necessary for successfully realising this potential through participatory evaluation. Findings indicated that while teachers and parents envision schools as territorial praesidiums, their focus remained primarily on student needs rather than those of the broader community. Despite a perceived increase in school smartness over seven years, there is a lack of corresponding attachment to the surrounding territory. As such, the paper suggests that enhancing the sense of belonging to the broader community requires efforts in collaboration, planning, and shared responsibility among stakeholders.

The article titled “*Real-Time Emotion Recognition and its Effects in a Learning Environment*” by Oihane Unciti, Antoni Martínez-Ballesté, and Ramon Palau [5] investigates the current use of emotion recognition technology in educational settings. It reviewed 1,347 studies spanning the last decade, with 43 selected for analysis. Despite a rise in research interest, particularly in online learning, practical implementation remains limited, with most studies in a theoretical stage. The Technological Readiness Level (TRL) indicates significant barriers to widespread adoption. The conclusions state that none of the examined studies have fully implemented emotion recognition in classrooms, and many lack validation and testing.

José Quiles-Rodríguez, Josep M. Mateo-Sanz, and Ramon Palau measured in their article titled “How does Coloured Lighting Influence the Affective Processes of Pupils?” [6] the impact of coloured light (i.e., natural light, orange, green, and purple) on the self-perception of energy, the self-perception of satisfaction, and the ability to produce more positive feelings in fifth-grade students. The experiment was conducted within a class of 20 students, and the LED lighting was positioned on the walls and near the windows. Their findings suggest that coloured light is related to the development

of certain affective processes in students. The impact, even with a certain tendency towards violet light, could be further emphasised if accompanied by dynamism.

María Libertad Aguilar Carlos, Jaime Muñoz Arteaga, Gabriela Citlalli López Torres, and José Eder Guzmán Mendoza propose in their article titled “Co-design a Digital Learning Ecosystem for Children with Disabilities: An Agile Model” [7] a novel technological ecosystem model using agile methodologies and design thinking tools to develop a digital learning ecosystem specifically tailored to children with disabilities. The authors adopted a co-design approach to implement the proposed model in a case study. While addressing deficiencies in traditional models, this research proposed an integrative model for children's rehabilitation services, using a technological ecosystem with active user involvement and demonstrated effectiveness in a case study involving a Rehabilitation Center and a School for Special Needs.

The article titled “Lib2Life – Digital Library Services Empowered with Advanced Natural Language Processing Techniques” by Melania Nitu, Mihai Dascalu, Maria Dorinela Dascalu, Laurentiu-Marian Neagu, and Maria-Iuliana Dascalu presents the Lib2Life platform, a digital library integrating Natural Language Processing (NLP) techniques designed to facilitate the preservation of historical documents provided by Central University Libraries in Romania. The platform includes several services available to the general public and librarians, including a processing pipeline for indexing scanned documents, semantic search capabilities, an ontology to organise and manage documents in a structured manner, as well as a recommendation engine. This paper aims to illustrate how the mix of culture and technology supports smart education in Romania through advanced NLP techniques and digitised libraries. The paper reports on developing a digital library that uses advanced NLP techniques to facilitate the digital transformation of historical documents.

The last two papers consider virtual environments and gamified experiences. The paper titled “Eathen Builder Simulation: Representing Natural Materials and Embodied Carbon With Computational Play” by Neil Potnis and Lola Ben-Alon considers natural building materials as a way to promote a decarbonized built environment. A virtual space was developed to facilitate this goal and represent low-carbon materiality within a simulation game for design and researchers. The experimental setup considered 24 playtests and showcased that a gamified interface engaged users into the pedagogy of decarbonized design technologies. Moreover, the study aimed to establish a digital foundation for a more comprehensive knowledge tool centred on earthen materials and life-cycle assessment. Lastly, the paper titled “Minecraft in STEAM education - applying game-based learning to renewable energy” by Tamás Kersánszki, Zoltán Márton, Kristóf Fenyvesi, Zsolt Lavicza, Ildikó Holik presented the potential of Minecraft to foster STEAM competences in a specific domain. The proposed framework was tested with 15 participants aged 10-16 exploring renewable energy sources with Minecraft during a summer camp. Their experience increased student

motivation and ensured productive task-solving and cooperation while working on sustainable development goals.

In conclusion, this Special Issue highlights the multifaceted and essential role that Smart Learning Ecosystems and Smart Digital Services play in navigating the twin transitions of our time. The selected papers illustrate how Smart Learning Environments can enhance educational experiences, promote sustainable development, and foster a deeper connection between individuals and their communities. The integration of digital technologies, while providing increasing benefits, also presents challenges that must be addressed with rigorous and sustainable approaches. The insights provided in this Special Issue underpin the necessity of continuous innovation and collaboration to create resilient, equitable, and Smart Learning Ecosystems.

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