EDITORIAL
AI AND IOT IN EDUCATION: TRAINING FOR INDUSTRY 5.0 AND SKILLS DEVELOPMENT IN THE 21ST CENTURY

Alejandro Lorenzo-Lledó[1*] iD , **Beatriz Amante García[2]** iD

[1]Universidad de Granada (Spain)

[2]Projectes d'Enginyeria, Universitat Politècnica de Catalunya (Spain)

Corresponding author: alorenzolledo@ugr.es

beatriz.amante@upc.edu

The rapid evolution of advanced digital technologies is producing profound transformations in educational systems worldwide. In particular, Artificial Intelligence (AI) and the Internet of Things (IoT) have become two of the most influential drivers in the redefinition of teaching and learning processes, shaping the roles of both teachers and students. In this regard, generative AI expands the possibilities for learning personalization, cognitive interaction, and real-time automation and feedback (Hrytsenko, Tkachenko, Podolyan, Dieiev & Ilyn, 2024; Koceski, Koceska, Lazarova, Miteva & Zlatanovska, 2025). As noted by Lorenzo, Meliá, Lorenzo-Lledó, Gadzhimusieva and Cerdán-Chacón (2025), this transformation involves not only incorporating technology, but also adapting and reinterpreting the pedagogical principles on which learning is structured within AI-mediated contexts.

For its part, the IoT is driving more connected and ubiquitous learning environments, where devices, sensors, and platforms interact with one another to generate more contextualized, data-driven learning experiences (Nuraini, Baharuddin, Sofeny, Pusitasari & Pardosi, 2024). This interconnected ecosystem enables the creation of intelligent environments capable of monitoring learning, adapting activities, providing access to personalized digital resources, and enriching the learning experience through dynamic representations of the physical and digital worlds (El-Haggar, Amouri, Alsumayt, Alghamedy & Aljameel, 2023; Kanan, Deshpande, Singh, Sharma & Taterh, 2023). Taken together, these possibilities position IoT as a key element for advancing more dynamic, adaptive, meaningful educational models that are aligned with the real needs of learning in the twenty-first century.

The growing implementation of these technologies coincides with a context of accelerated change in which educational systems are expected to foster new cognitive, digital, socioemotional, and ethical competencies in students. Recent reviews (Almatrafi, Johri & Lee, 2024; Zhang, Zhang, Shen, Liu, Wang, Gašević et al., 2024) show that generative AI and intelligent environments not only transform teaching–learning methodologies, but also require the development of advanced digital literacy, critical thinking, and an ethical competence surrounding AI. At the same time, it has become essential to prepare teachers to integrate these tools in a pedagogically sound and contextually grounded manner (Dringó-Horváth, Rajki & T. Nagy, 2025).

Nevertheless, despite the benefits and opportunities offered by AI and IoT, the expansion of these technologies also presents challenges and risks related to privacy, algorithmic transparency, data governance, and equity in access to resources. As Williamson and Eynon (2020) note, the emergence of AI in educational institutions introduces forms of algorithmic surveillance and shifts decisions traditionally made by humans toward automated mechanisms, with the risk of reproducing inequalities and biases. In this line, Holmes and Porayska-Pomsta (2023) warn that the adoption of AI in education requires strong ethical frameworks that regulate the

handling of sensitive data and ensure that automated decisions respect students' rights and needs. In this respect, AI should not be used to exclude but rather to deepen educational inclusion, as it can serve as an instructional support tool for learners with special educational needs, such as children with autism (Lorenzo Lledó, Lorenzo-Lledó & Rodríguez-Quevedo, 2024). For these reasons, the incorporation of AI must be accompanied by institutional policies that guarantee sustainable and inclusive use for the entire educational community.

In this context, scientific research plays a decisive role, and it is within this framework that the present special issue acquires its full meaning. Exploring the pedagogical, technological, and social implications of AI and IoT makes it possible to move toward educational models that harness the potential of intelligent systems without abandoning the human dimension of learning. In this regard, investigating, reflecting upon, and providing empirical evidence concerning the use of AI and IoT from diverse and complementary perspectives contributes to a deeper understanding of ongoing changes and enables the appropriate planning and guidance of educational actions.

The contributions included in this special issue form an interdisciplinary mosaic that reveals both the opportunities and the challenges posed by AI and IoT in contemporary education. The issue features studies examining the impact of generative AI tools on students' performance and motivation, as well as analyses of student satisfaction and the factors influencing the intention to use AI-based tools; validations of instruments designed to assess both AI competence and perceptions of the impact associated with AI use in educational contexts; investigations exploring the self-efficacy, attitudes, and predisposition of future teachers to integrate AI into their teaching practice; innovative teaching proposals mediated by AI tools; and technical approaches that apply machine learning algorithms to understand complex educational phenomena. The issue is further enriched by critical analyses addressing the benefits, ethical risks, and privacy concerns associated with generative AI in education, along with studies that examine emerging sociopsychological aspects such as perceived pressure from automation and AI literacy as a motivational factor.

This special issue brings together a total of eleven articles from different countries, institutions, and cultural contexts, reflecting the international scope of the current debate on the integration of AI and IoT in education. The contributions display a notable methodological diversity, including structural equation models, psychometric analyses, quasi-experimental designs, innovative teaching proposals, critical analyses, and technical comparisons based on machine learning. Furthermore, in the selection of the papers, priority was given to empirical studies with clear practical implications, avoiding the inclusion of purely theoretical reviews and favoring research aimed at transforming educational practice. This plurality of approaches and the emphasis on empirical evidence with practical application not only enrich the understanding of the phenomenon but also make it possible to observe how AI is being integrated in diverse educational contexts, offering a broad and representative vision of the multiple ways in which it is entering educational practice and contributing to the redefinition of its dynamics and processes.

The order in which the articles are presented in this special issue follows an editorial criterion designed to offer a coherent and progressive reading. First, the issue includes studies that examine the personal, attitudinal, and contextual factors that influence the adoption and use of AI in education, providing an essential interpretative framework for understanding how students' and future teachers' dispositions, beliefs, and motivations are shaped in relation to the adoption and integration of AI in educational contexts. Subsequently, the issue presents studies focused on the validation of specific instruments designed to assess AI competence and perceptions related to its impact, offering robust scales that may be used in future research. This is followed by articles that develop AI-supported educational interventions, presenting empirical evidence on their potential to enhance learning, strengthen competencies, and enrich teaching processes. This sequence leads into a critical analysis centered on ethical and privacy issues associated with the use of generative technologies, encouraging reflection on their responsible adoption in educational settings. Finally, the issue concludes with a technical study based on machine learning models, representing the most specialized and computational contribution within the special issue. This

progression —from the explanatory/predictive to the instrumental, from the applied to the reflective/analytical, and from the pedagogical to the computational— enables readers to understand in an integrated manner the diverse dimensions that shape the role of AI in current educational processes.

With this general framework established, the eleven articles that form part of the issue are presented below, following the sequence previously described.

1. Ygnacio Tomaylla-Quispe, Gerber Pérez Postigo, Olger Gutiérrez-Aguilar, Sandra Chicaña-Huanca, and Aleixandre Duche-Pérez present Artificial intelligence on student satisfaction in higher education: The role of positive attitude, continuous use intention, and perceived usefulness, an explanatory model that examines the factors influencing university students' satisfaction with AI tools. Using structural equation modeling, the authors demonstrate the mediating role of positive attitude, continuous use intention, and perceived usefulness, offering key insights into the effective adoption of these technologies. Their conclusions are particularly relevant for the sustainable integration of AI in higher education.

2. Maricel Amandoron, Cleford Yanson, Sherelyn Banzon, Joy Salundaguit, Lenny Rose Tejero, Ryan Mahilum, Emerita Tan, Lynne Graham-Wilberforce, Christeodoflor Ramos, Edralin General, Reynaldo Jr. Tondo, Gerly A. Alcantara and Romel Mutya examine in Preservice science teachers' preparedness for integrating AI in science teaching: A Structural Equation Modeling approach the self-efficacy, attitudes, and level of preparedness of preservice science teachers to integrate AI into science instruction. Through a structural equation modeling approach, the authors identify the factors that predict this level of preparedness. The study offers relevant implications for designing training programs that strengthen teachers' competence in AI integration.

3. Nguyen Mau Duc, Vu Thu Trang, Tran Thi Tuoi, Pham Thi Hong Hanh, and Nguyen Minh Tuan analyze in The impact of pressure from being replaced by artificial intelligence on the career activities of pre-service teachers the psychological pressure experienced by preservice teachers due to the fear of being partially or fully replaced by AI systems. The study, based on a correlational approach with predictive models, shows how these perceptions influence their professional expectations and the construction of their teacher identity. This work contributes to understanding the sociopsychological challenges that accompany the integration of AI in education and highlights the need for institutional support to mitigate technological anxiety in teacher training.

4. Ma. Kristine Grace Ocado, in More than skills: How AI literacy shapes student motivation in the age of Education 4.0, examines in depth how AI literacy influences the motivation of higher education students. Through a correlational analysis, she identifies significant relationships between knowledge about AI, attitudes toward technology, and academic motivation. Her findings highlight the relevance of integrating AI-related content into curricula as a way to strengthen students' motivation and engagement in advanced digital learning environments.

5. María-Inmaculada Jiménez-Perona, Miguel-Ángel Fernández-Jiménez, Dolores Pareja-de-Vicente, and Juan-José Leiva-Olivencia, in Evaluation of the impact of the use of generative artificial intelligence in higher education: EPGAI-ES Scale, design and validate a scale aimed at assessing the perceived impact of generative AI in university settings. Through advanced psychometric analyses, they identify key dimensions related to usefulness, ethics, and effects on learning. The resulting instrument offers a robust and rigorous tool for educational research, enabling institutions and scholars to systematically evaluate the integration of generative AI in higher education.

6. María Rubio-Gragera, Antonio de Padua Palacios-Rodríguez, and Ernesto Colomo-Magaña, in Validation of a digital competence in artificial intelligence scale for non-university students based on the DigComp model, present the validation of a scale designed to assess AI competence in students at pre-university educational levels. The instrument, grounded in the DigComp framework, measures skills related to computational thinking and interaction with intelligent systems. Psychometric analyses confirm

its reliability and validity, making it an essential tool for assessing emerging digital literacy levels in school-age learners.

7. Abdelrahman Elhag, Maimoona Al Abri, and Ahmed Mohamed Fahmy Yousef, in their article The effect of generative AI tools (ChatGPT, Gemini, etc.) on students' achievement and their motivation towards learning, analyze the impact of generative AI tools on students' academic performance and motivation. Through a quasi-experimental design, they examine how the incorporation of these technologies into learning activities influences students' participation and academic outcomes. The study provides relevant empirical evidence on how generative AI can be effectively integrated into instructional strategies, contributing to educational innovation in formal learning environments.

8. Bayu Setiaji, Heru Kuswanto, Yusman Wiyatmo, Riki Perdana, Pujianto Pujianto, Devinda Putri Maharani, Nely Nikmah Fadillah, and Asya Maulida Sakinata present Gudeg Meets AI: A culturally integrated discovery learning e-book to evolute creative thinking and physics identity, an innovative instructional proposal that integrates local cultural content with AI-based resources. Through a quasi-experimental design, they assess the impact of the e-book on students' creative thinking and physics identity. The results show significant improvements, demonstrating the potential of integrating AI, culture, and active pedagogies to foster more meaningful and contextually grounded learning.

9. Ronilo Antonio, in Fostering preservice science teachers' AI-Tpack competence and reflections through an AI-focused pedagogical learning course, presents a training intervention aimed at strengthening AI-TPACK competencies in preservice science teachers. The course integrates reflective activities and practical experiences with AI tools, with significant improvements observed in participants' pedagogical, technological, and disciplinary abilities. The study highlights the importance of incorporating AI into initial teacher education.

10. Alex Vallejo Blanxart and Ruben Nicolas Sans, in The role of generative AI chatbots in higher education: A student-centric conceptual analysis of benefits, ethics, and privacy concerns, conduct a conceptual analysis focused on the benefits, ethical risks, and privacy concerns arising from the use of generative AI chatbots in higher education. The study examines student perspectives and emerging debates, providing a framework for comprehensively understanding the implications of these tools. Its contribution is key for guiding institutional policies and promoting the responsible use of generative AI in university contexts.

11. John Paul Miranda, Rex Bringula, Nelson Rodelas, Carmelita Ragasa, Edie Boy Dela Cruz, Sheila Geronimo, Arlene Mae Valderama, Albert Vinluan, and Alexis John Rubio, in Comparing supervised learning models for classifying learned helplessness in a mathematics tutoring environment, examine the use of supervised learning models to classify states of learned helplessness in mathematics tutoring settings. They compare different algorithms and highlight the potential of AI-based analytics to understand students' emotional patterns and support personalized interventions, opening new avenues for intelligent tutoring systems.

This selection of articles constitutes a valuable contribution to advancing knowledge on the integration of artificial intelligence in education, offering empirical evidence, validated instruments, and pedagogical proposals that help to better understand its impact on teaching and learning processes. The contributions gathered here reveal both the transformative potential of AI and the ethical, educational, and sociocultural challenges that accompany its development, inviting the international scientific community to continue investigating and reflecting on its responsible and inclusive implementation.

It is hoped that the works presented will serve as a starting point for new research, debates, and educational practices that foster a critical, ethical, and pedagogically robust incorporation of AI and IoT across diverse educational contexts.

Keywords - Artificial Intelligence in Education, Internet of Things (IoT), AI literacy, Generative AI, Digital Competence, Innovative Pedagogies.

Declaration of Conflicting Interests

Funding

References

Almatrafi, O., Johri, A., & Lee, H. (2024). A systematic review of AI literacy conceptualization, constructs, and implementation and assessment efforts (2019–2023). *Computers & Education Open*, 6, 100173. https://doi.org/10.1016/j.caeo.2024.100173

Dringó-Horváth, I., Rajki, Z., & T. Nagy, J. (2025). University Teachers' Digital Competence and AI Literacy: Moderating Role of Gender, Age, Experience, and Discipline. *Education Sciences,* 15(7), 868. https://doi.org/10.3390/educsci15070868

El-Haggar, N., Amouri, L., Alsumayt, A., Alghamedy, F. H., & Aljameel, S. S. (2023). The effectiveness and privacy preservation of IoT on ubiquitous learning: Modern learning paradigm to enhance higher education. *Applied Sciences,* 13(15), 9003. https://doi.org/10.3390/app13159003

Hrytsenko, V., Tkachenko, A., Podolyan, O., Dieiev, K., & Ilyn, L. (2024). The role of artificial intelligence in personalisation of the learning process. *Revista EDaPECI,* 24(3), 152–165. https://doi.org/10.29276/redapeci.2024.24.320987.152-165

Holmes, W., & Porayska-Pomsta, K. (2023). *The ethics of artificial intelligence in education: Practices, challenges, and debates.* Routledge.

Kanan, T., Deshpande, S., Singh, R., Sharma, T., & Taterh, S. (2023). Exploring the potential of IoT-based learning environments in education. *International Journal of Advanced Smart Computing and Applications,* 4(1), 26–36.

Koceski, S., Koceska, N., Lazarova, L.K., Miteva, M., & Zlatanovska, B. (2025). Exploring the performance of ChatGPT for numerical solution of ordinary differential equations. *Journal of Technology and Science Education,* 15(1), 18-34. https://doi.org/10.3926/jotse.2709

Lorenzo, G., Meliá, S., Lorenzo-Lledó, A., Gadzhimusieva, D., & Cerdán-Chacón, A. (2025). The application of artificial intelligence in educational environments for autistic learners: Analysis of research lines using VOSviewer. *Interactive Technology and Smart Education.* https://doi.org/10.1108/ITSE-04-2025-0081

Lorenzo Lledó, G., Lorenzo-Lledó, A., & Rodríguez-Quevedo, A. (2024). Análisis mediante inteligencia artificial de las emociones del alumnado autista en la interacción social con el robot NAO. RED. *Revista de Educación a Distancia,* 24(78). https://doi.org/10.6018/red.588091

Nuraini, R., Baharuddin, D., Sofeny, D., Pusitasari, M. D., & Pardosi, V. B. A. (2024). Use of the Internet of Things (IoT) in the context of ubiquitous learning in higher education. *Journal of Social Science Utilizing Technology,* 2(1), 39–51. https://doi.org/10.70177/jssut.v2i1.744

Williamson, B., & Eynon, R. (2020). Historical threads, missing strands, and future patterns: Artificial intelligence and educational technology. *Learning, Media and Technology,* 45(3), 223–235. https://doi.org/10.1080/17439884.2020.1798995

Zhang, X., Zhang, P., Shen, Y., Liu, M., Wang, Q., Gašević, D. et al. (2024). A Systematic Literature Review of Empirical Research on Applying Generative Artificial Intelligence in Education. *Frontiers of Digital Education,* 1(3), 223–245. https://doi.org/10.1007/s44366-024-0028-5

To cite this article: