



## SMART EDUCATION FOR THE 21ST CENTURY: POST-DIGITAL ERA AND EMERGING DIVIDES

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### KEYWORDS

*Smart technology*  
*Postdigital education*  
*Digital divide*  
*Educational equity*  
*Artificial intelligence*  
*Digital competency*

### ABSTRACT

*This article examines the integration of smart technologies (ST) in education, highlighting opportunities such as personalized learning while also addressing challenges such as equity and access. Through a bibliographic analysis of regulations and curriculum trends in the US and Europe, pedagogical practices and design criteria that promote an ethical and effective use of ST are identified. The findings reveal a significant digital divide in education involving artificial intelligence (AI), underscoring the need to foster both technological and human competencies. The article proposes an approach that combines the use of AI with training in critical skills within intercreative digital environments, while addressing the socio-emotional needs of students. In conclusion, the study emphasises the importance of developing educational frameworks that effectively integrate AI, addressing ethical and social challenges to ensure a more inclusive and adaptive learning experience.*

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## 1. Introduction

### 1.1. *IT and the Post-Digital Society: The Digital Divide in Access*

In the post-digital era, technology has ceased to be novel and has become an essential and ubiquitous part of everyday life, an imposed reality (López-Rey, 2024). In this context, smart technologies (ST) represent an evolution towards a more effective integration with the human element, combining hardware and software to automate tasks and decisions, collect and analyse data, and facilitate communication between devices (Harrold, 2020). These devices, initially deployed in the context of Industry 4.0, are facilitating transformative changes across a range of sectors, including healthcare (Ha et al., 2023), environmental management (Batta and Bharti, 2022) and education (Mykhailov, 2023), through the utilisation of the Internet of Things (IoT).

While significant advances are anticipated with the expansion of AI (Anderson and Rainie, 2023), challenges also emerge for democracies (López Ponce et al., 2024) or security, privacy and access, particularly affecting vulnerable populations (Castañeda and Williamson, 2021). It is therefore imperative that the techno-ethical challenges associated with these developments are addressed in order to protect society. The digital divide is evidenced by studies indicating that workers with higher incomes are more likely to utilise AI than those with fewer resources, which could serve to accentuate labour divisions (The Adecco Group, 2024). Furthermore, the lack of sufficient training underscores the need for training and equitable access.

In the field of education, the utilisation of smart devices has the potential to enhance the learning environment, facilitating more effective pedagogical approaches and fostering adaptive and personalised learning experiences that are responsive to the diverse needs of students (Chen et al., 2021). Consequently, technology serves as a catalyst for advancing educational practices and processes (Cheung et al., 2021). The concept of smart education is comprised of three principal elements: smart pedagogy, smart learning and smart educational technologies (Mykhailov, 2023). It is of paramount importance to equip the future workforce with skills that are aligned with the demands of the economy (UNESCO IITE, COL and UNB, 2022). Furthermore, these innovative educational environments have the potential to enhance traditional teaching methods, facilitating deep learning and critical thinking (Zhang et al., 2023).

### 1.2 *Post-Digital Education: From Dystopia to New Utopias*

The adoption of ST in the field of education, particularly those based on artificial intelligence (AI), will have a profound impact on the education community. This challenge can be addressed through post-digital dialogue, which emphasises the importance of developing new competencies for both students and teachers. In order to work effectively in digital and AI environments, it is essential to gain a comprehensive understanding of the tools in question, as well as their functionality and inherent limitations. This should be situated within a post humanist conceptualisation of education, which rejects the dichotomy between the human and the non-human, and instead advocates for integrated collaboration in knowledge production (Mañero, 2023).

The advent of AI and automation, coupled with climate change and the indiscriminate use of natural resources, is precipitating structural transformations that serve to exacerbate existing inequalities and challenge the capacity of education to be both equitable and transformative (Almazán-López and Osuna-Acedo, 2024). In response to these developments, the need for a new educational contract based on a global ethic that promotes peaceful societies and shared progress has been raised (UNESCO, 2022). It is incumbent upon governments to cultivate new narratives of the future and integrate a civic ethic into curricula that promotes shared values and restores social trust (Organisation for Economic Co-operation and Development [OECD], 2019).

The advent of post-digital ecopedagogies, as a nascent corpus of educational approaches, challenges the established structures of traditional pedagogical practice and proffers novel methodologies for navigating the intricacies of post-digital ecosystems. It is imperative to rethink education in this context in order to facilitate social and ecological transformation towards a more just and reflective future (Jandrić and Ford, 2022). These new educational utopias must aspire to the principles of equity, social justice, environmental sustainability, diversity and inclusion, and the fostering of creativity, empathy and collaboration. Education and research should act as catalysts for social transformation, inspiring

the construction of a world that is more humane and respectful of all forms of life (Escaño and Mañero, 2022).

### **1.3. The Need for this Research**

It is of the utmost importance to conduct research that examines the current perspectives and approaches to teaching AI competencies. By examining the most effective practices and pedagogical methodologies through an analysis of recent literature and institutional curriculum proposals, we can develop a robust framework for effective and up-to-date AI education. Such research would also assist in identifying design criteria and pedagogical approaches that address ethical and social challenges, thereby ensuring the responsible use of ST in education. It is imperative to propose solutions that consider both the perspectives of educators and the regulatory framework that governs the integration of ST into the educational domain. Doing so will facilitate a more ethical and effective integration of ST, benefitting educators and students alike. The principal objectives of this research are as follows:

1. To analyse the current perspectives and approaches to teaching AI competencies.
2. To identify the design criteria and pedagogical approaches that address the ethical and social challenges inherent in the implementation of ST in education.

## **2. Methodology**

This exploratory research is based on an in-depth literature review to identify pedagogical trends in the US and Europe on the use of IT in education. The objective is to provide guidance for the design of teaching tools and practices that minimise risks and maximise opportunities. A comprehensive review of the scientific literature, regulations, pedagogical frameworks and actual use cases was conducted, employing data triangulation to enhance the validity and reliability of the findings (Hanson-DeFusco, 2023).

- Scientific and policy databases consulted: The following keywords were used in academic databases such as Web of Science, Scopus and Dimensions: "Education", "Curriculum", "Skills", "Smart Technologies", "Artificial Intelligence" and "Emerging Technologies". Furthermore, European, US and international curriculum proposals and normative sources were consulted.
- Web research and news analysis: To supplement the analysis, a review was conducted of news, statistics, and articles from recognized websites concerning the impact of AI in education. Those articles that offered pedagogical and technological solutions were selected for further examination. Furthermore, a Google alert was initiated with the following search term: The search terms "AI AND Risk AND Benefit AND Education".

## **3. Results**

### **3.1. Learning to Collaborate with Humans and AI in Digital Spaces: From Creativity to Inter-Creativity**

Education serves as a conduit, facilitating the alignment of labour market demands, human development, and the concerns of families and educators. It is of the utmost importance to strike a balance between the utilisation of digital technologies and the cultivation of essential human abilities. The capacity to collaborate with AI systems and others to solve problems and create knowledge, as well as the ability to reflect on the ethical implications of technology (Markauskaite et al., 2022), must be balanced with communicative, motor and socio-emotional competence, which should be fostered through traditional classroom activities and practical applications of the curriculum.

Creativity is a fundamental component in addressing the challenges of the 21st century (Fernández Souto and Balonas, 2021). It enables students to face new challenges and find solutions in any field (Habib et al., 2024). As Chirico et al. (2018) observe, creativity encompasses the generation of original ideas with intrinsic value and utility, encompassing both the production of novel concepts and the capacity to select the most promising ones. In a recent study, Habib et al. (2024) examined the impact

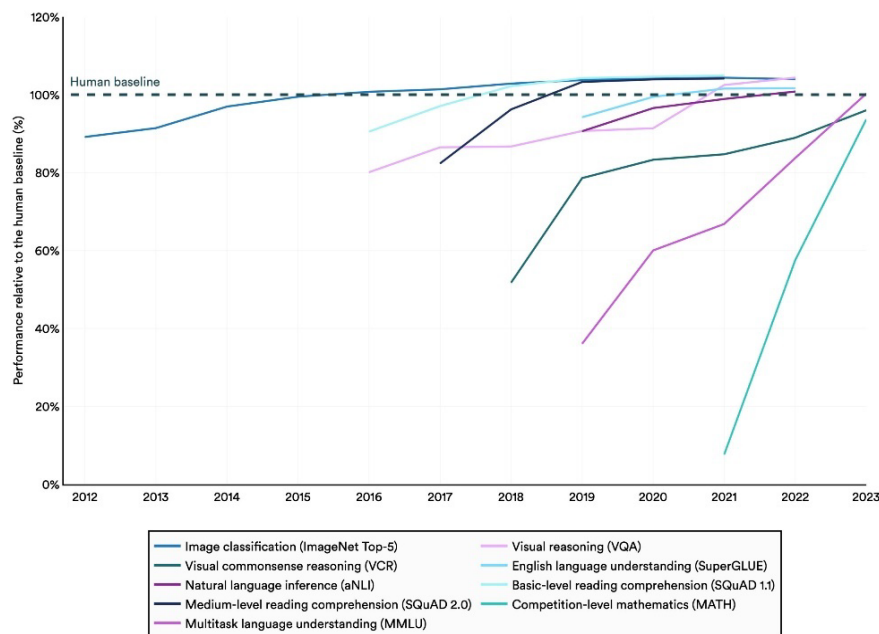
of AI on students' creative thinking, concluding that while AI can support the creative process, it can also have a detrimental effect on students' confidence and creativity.

Marrone et al. (2022) identified that students value AI support for accessing information and enhancing their creativity. However, they also expressed concerns about a possible decrease in their social skills and the rigidity of AI-mediated tasks. Similarly, Darvishi et al. (2024) observed that while AI enhances feedback and personalisation of learning, its excessive utilisation may constrain students' autonomy and self-regulation. Abbas et al. (2024) demonstrated that the frequent utilisation of ChatGPT can foster procrastination and result in diminished academic achievement. Furthermore, Bastani et al. (2024) indicated that, although GPT-4 based tutors enhance performance in practical problem solving, their subsequent discontinuation may result in a decline in learning over time. Finally, Nie et al. (2024) found that the use of GPT-4 in a massive programming course at Stanford improved test scores but reduced student engagement, which leaves open the debate about the impact of AI on their long-term learning.

The majority of teachers concur with the utilisation of AI in the classroom. While these tools have the potential to enhance learning autonomy and foster creativity in educational processes (Numa-Sanjuán et al., 2024), they also present significant challenges, including the necessity for constant updating in technological knowledge. This is due to the rapid evolution of AI, which requires educators to maintain currency in the field in order to apply it effectively in teaching (Cordero Monzón, 2024). Moreover, the integration of AI presents significant ethical challenges, including ensuring the responsible use of these technologies, preventing plagiarism and maintaining academic integrity. It is also imperative to prevent an excessive reliance on technology, which could impair students' capacity to cultivate critical and creative thinking (Gallent-Torres et al., 2023). Furthermore, at the institutional level, there are additional constraints to the implementation of AI by teachers, due to limitations in resources and training, which may impede their capacity to fully leverage these tools in their pedagogical practices (Montiel-Ruiz and López-Ruiz, 2023).

The generation of original ideas is dependent upon a combination of experience, emotion and intuition, which collectively constitute human creativity. Despite the absence of these attributes in AI, it is capable of emulating creativity through sophisticated data processing. It is capable of replicating the creative abilities of the humans from whom it has been trained, including their biases and errors (H. Wang et al., 2024). While AI has made remarkable progress, outperforming humans in many engineering tasks (Figure 1), it faces a significant challenge: the potential scarcity of high-quality training data (Villalobos et al., 2024).

GPT-4 has been demonstrated to outperform 91% of humans on the Alternative Uses Test for measuring creativity (Haase and Hanel, 2023) and 99% on the Torrance Tests of Creative Thinking (Neuroscience, 2023). Nevertheless, while AI-generated ideas may occasionally exhibit greater originality, they frequently prove less practical than those proposed by human experts (Si et al., 2024). The ideas generated when humans and AI collaborate are often more novel and interesting than those generated by humans alone. However, highly creative individuals require less assistance from AI, and the ideas generated by AI tend to be more similar to each other (Doshi and Hauser, 2023). Nevertheless, collaborative work with AI can help to balance competencies and increase productivity, particularly for those with less experience (Brynjolfsson et al., 2023; Noy and Zhang, 2023).

**Figure 1.** Technical performance of AI. Selected measurements, 100%= human reference

Source: AI Index Steering Committee and Institute for Human-Centered AI (2024, p. 81).

There are notable discrepancies between the outcomes achieved by students and professionals when utilising AI. In certain professional sectors, collaboration with AI can facilitate enhanced creativity and improve performance in key tasks. Nevertheless, in the context of education, the advantages of AI for students may not necessarily outweigh the disadvantages. This is partly due to the tendency of technological determinism to overvalue technology as the ultimate solution to educational challenges, thereby disregarding crucial aspects such as pedagogy, equity and critical reflection (Mañero, 2023). Nevertheless, a post-digital pedagogy that orientates the utilisation of technology towards the promotion of autonomy, creativity and participation could facilitate students' capacity to become active agents of their own learning. This would optimise the performance of AI in the classroom while minimising its adverse effects (López-Rey, 2024).

The implementation of intercreative strategies, including collaboration with non-human entities, is of paramount importance in the current social context, where participation and communication are fundamental (Mañero and Escaño, 2022), particularly in open and collaborative digital environments. Such environments not only facilitate intercreative practices but also engender the values that arise from them. It is imperative to adopt post-digital pedagogies that challenge traditional educational models, rejecting both technological determinism and the mere instrumentalisation of technology. In contrast, we put forth a posthumanist perspective (Mañero, 2023), one that is both critical and non-dualist, which addresses the hybridization of the digital and the analogical as an inherent aspect of the human condition.

### **3.2. Critical AMI: Addressing the Great Digital Divide on AI**

The incorporation of AI, algorithms and extensive data processing in the realms of education and communication gives rise to challenges that may impinge upon autonomy and critical decision-making (Nemorin et al., 2023). This suggests that traditional critical pedagogy may be inadequate for navigating the new technological paradigm (Almazán-López and Osuna-Acedo, 2023), necessitating a rethinking of the human-machine relationship. Furthermore, the increasing prevalence of generative AI has served to reinforce this necessity. In response, UNESCO, governments and educational institutions and organisations dedicated to improving education through technological innovation are working to develop and implement intentional and systematic educational strategies that integrate AI.

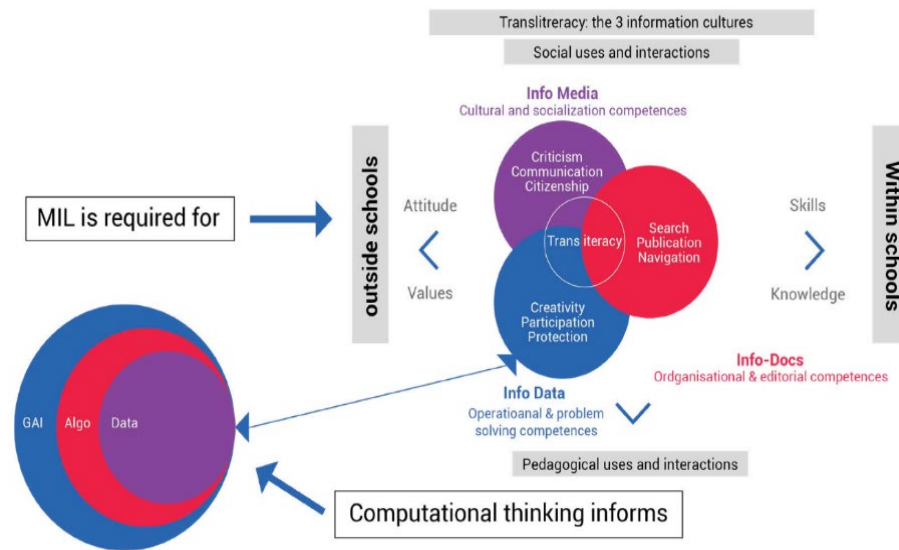
A study conducted by UNESCO (2023b) on the implementation of AI curricula indicates that, of the 193 member states contacted, only 11 have developed and implemented AI curricula, as illustrated in Table 1. This is indicative of a substantial digital divide. For effective integration into curricula, it is essential that governments demonstrate strong commitment, establish validation mechanisms and provide teacher training.

**Table 1.** AI curricula for basic education approved and implemented by governments

Country/ region	Curriculum title	Curriculum developer <sup>15</sup>	Educational levels		
			Primary	Middle	High
Armenia	Curriculum of ICT	Government		X	X
Austria	Data Science and Artificial Intelligence	Federal Ministry of Education, Science and Research			X
Belgium	IT Repository	<i>Fédération Wallonie-Bruxelles</i> (French-speaking Community of Belgium)			X
China	AI curriculum embedded in the Information Science and Technology curriculum	The Ministry of Education of the People's Republic of China	X	X	X
India	Atal Tinker Labs AI modules	Atal Tinker Labs, Atal Innovation Mission, NITI Aayog		X	X
Republic of Korea	'AI Mathematics' under the Mathematics Subject Group for high schools	Korea Foundation for the Advancement of Science and Creativity			X
	'AI Basics' under Technology Home Economics Subject Group for high schools	Korea Foundation for the Advancement of Science and Creativity			X
Kuwait	Standards curriculum	Curricula technical guidance experts and teachers	X	X	
Portugal	Information and Communication Technologies	State school teachers of ICT and Mathematics	X	X	X
Qatar	Computing and Information Technology	Binary Logic, Ministry of Education and Higher Education	X	X	X
	Computing and Information Technology (High Tech Track)	Binary Logic, Ministry of Education and Higher Education			X
Serbia	Informatics and programming – Grade 8	Ministry of Education working group		X	
	Modern technologies in gymnasiums – Grade 3 and 4	Ministry of Education working group			X
United Arab Emirates	AI curriculum embedded under the Technology Subject Framework	Ministry of Education	X	X	X

Source: UNESCO (2023b, p. 19).

UNESCO recommends that learning about AI be integrated into a broader media and information literacy (MIL) curriculum, rather than treated as a stand-alone subject. This integration is based on the idea that AI is a natural extension of the skills that individuals should develop through MIL, such as critical thinking, digital literacy and the ability to judge the veracity of information. MIL encompasses not only access to and use of information, but also an understanding of the underlying technologies, such as AI, that influence how information is created, distributed and consumed. UNESCO advocates an educational approach where AI is part of a comprehensive digital literacy education that enables students not only to use technology effectively, but also to understand its ethical and social implications. This holistic approach is consistent with MIL as a form of transliteracy that adapts to the everyday experiences of people as they interact with different forms of information, build knowledge, shape their identities and make decisions (Frau-Meigs, 2024).

**Figure 2.** AI literacy in the MIL framework

Source: Frau-Meigs (2024, p. 7).

Key skills in an AI-saturated world include interpreting the output of AI systems, integrating it with human knowledge, assessing its ethical implications, and elevating human cognitive work towards creativity and meaning (Markauskaite et al., 2022). It is therefore essential to educate individuals from an early age on the responsible use of technology. MIL should be seen as a fundamental right that enhances quality of life, fosters lifelong learning and cultivates critical and participatory citizens (Almazán-López and Osuna-Acedo, 2023). This requires a critical MIL framework that incorporates AI (UNESCO, 2023a) and prioritises its ethical implementation (Miao and Holmes, 2024) as a response to the global digital divide.

### 3.3. Proposals to Enhance AI Competencies for Students and Educators: EU, US, and UNESCO

Digital competencies in Europe are framed within the Digital Competence Framework for Citizens (DigComp 2.2) (Riina Vuorikari et al., 2022), which outlines the essential skills required to participate in the digital society, including the use of advanced technologies such as AI, IoT, and remote work. The latest version of DigComp emphasises the importance of understanding the ethical use of AI and its societal impact, focusing on five key areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. These areas aim to equip individuals with the necessary skills to navigate a digital landscape shaped by advanced technologies and to ensure their responsible and effective integration into society.

The European Digital Competence Framework for Educators (Redecker and Punie, 2017), derived from DigComp, provides support for educators at all levels of education in effectively integrating digital technologies, such as AI, into their pedagogical practice. This framework is applicable in both formal and non-formal education and training contexts, without establishing a normative framework. Rather, it provides a common basis for analysis and dialogue on teachers' digital competence in the EU. Furthermore, a self-reflection tool, SELFIEforTEACHERS (Economou, 2023), has been developed with the objective of enabling primary and secondary teachers to assess and improve their digital competence, thereby facilitating the planning of professional development based on the results of these self-assessments.

Although the United States does not possess a unified federal framework analogous to the European DigCompEdu, a multitude of initiatives spearheaded by educational institutions, nonprofit organizations, and the private sector are striving to delineate AI competencies. These endeavours concentrate on technology integration, professional development and the advancement of global educational standards, offering supplementary methodologies for the ethical implementation of AI in

education. Furthermore, companies such as Microsoft, Intel and IBM provide curricula that have already been adopted by some states and other governments.

Additionally, there are independent endeavours that are not affiliated with specific products or curricula that have had a notable influence. The AI4K12 initiative, which was launched in 2018, has the objective of establishing national guidelines for the teaching of AI at all levels of education, from pre-school through to high school. The initiative places particular emphasis on the development of conceptual understanding, ethical design, and the application of AI to real-world problems. Its aim is to prepare students for careers in an AI-driven world. The K-12 Computer Science Framework (K12CS), which was launched in 2016 and developed by organisations such as ACM and Code.org, established the foundation for the teaching of technology skills and computational concepts at all levels of education. It promoted computational thinking and complex problem solving, although it did not focus exclusively on AI.

The 2030 Agenda, which was adopted in September 2015 by all UN member states, represents a global plan of action with the objective of eradicating poverty and achieving sustainable development by 2030. The 2030 Agenda is articulated in 17 Sustainable Development Goals (SDGs) and 169 specific targets that address social, economic and environmental challenges (United Nations [UN], n.d.). Goal 4, which focuses on ensuring inclusive, equitable and quality education, is pivotal to achieving the other SDGs. This is because education is recognised as an essential enabler of sustainable development and empowerment (Miao and Cukurova, 2024). In alignment with this objective and its role in the implementation of the 2030 Agenda, UNESCO has developed an AI Competency Framework for learners and a parallel framework for teachers, which builds upon its existing ICT Competency Framework for Teachers (UNESCO, 2019).

The UNESCO AI Competency Framework for Students (Miao and Shiohira, 2024) has been developed with the objective of preparing students to become responsible users and co-creators of AI. The framework is based on three principles: proactivity, with the objective of developing competencies that will enable the shaping of ethical and sustainable AI; critical competence, with the aim of developing responsible users and leaders in the design of AI technologies; and humanity, with a focus on an ethical and just approach. The framework comprises 12 competences distributed across four dimensions, as illustrated in Table 2.

**Table 2.** AI Competency Framework for Students

Competency aspects	Progression levels		
	Understand	Apply	Create
• Human-centred mindset	• Human agency	• Human accountability	• Citizenship in the era of AI
• Ethics of AI	• Embodied ethics	• Safe and responsible use	• Ethics by design
• AI techniques and applications	• AI foundations	• Application skills	• Creating AI tools
• AI system design	• Problem scoping	• Architecture design	• Iteration and feedback loops

Source: Miao and Shiohira (2024, p. 19).

The objective of the AI Competency Framework for Teachers (Miao and Cukurova, 2024) is to equip teachers with the requisite skills to integrate AI into teaching in an effective and ethical manner, as outlined in Table 3. In light of the transformative impact of AI on the teacher-learner dynamic, the framework reimagines the teaching role. Furthermore, this framework emphasises the necessity of safeguarding the rights of teachers and advancing technological sustainability. It serves as a global reference point for national AI competency frameworks and teacher education programmes, with the objective of achieving a more inclusive and equitable education.



**Table 3.** IA competency framework for teachers

Aspects	Progression		
	Acquire	Deepen	Create
1. Human-centred mindset	Human agency	Human accountability	Social responsibility
2. Ethics of AI	Ethical principles	Safe and responsible use	Co-creating ethical rules
3. AI foundations and applications	Basic AI techniques and applications	Application skills	Creating with AI
4. AI pedagogy	AI-assisted teaching	AI-pedagogy Integration	AI-enhanced pedagogical transformation
5. AI for professional development	AI enabling lifelong professional learning	AI to enhance organizational learning	AI to support professional transformation

Source: Miao and Cukurova (2024, p. 22).

While both AI competency frameworks concentrate on the K-12 level of education, they emphasise the significance of higher education in teacher training and AI integration. The ability to demonstrate AI literacy is considered a fundamental right, and it is essential for educators to have a high level of proficiency in this area in order to effectively teach their students (Miao and Cukurova, 2024).

In both the European Union and the United States, the integration of AI competencies in education is intended to cultivate technical abilities, ethical discernment, and prepare students for the complexities of these technologies. Both approaches emphasise the necessity of approaching AI with responsibility and critical awareness. However, a 2023 UNESCO study indicates that these ideas have yet to be effectively implemented in compulsory education. In order to achieve this, UNESCO proposes a more holistic and interdisciplinary approach to teaching AI, which would entail a redefinition of the role of teachers in this context.

## 4. Discussion and Conclusions

### 4.1. Educational Technologies (ET) and Smart Technologies (ST): Towards Smart Education

The evidence regarding the impact of ET is limited and often biased (UNESCO, 2023c). Although these technologies have the potential to enhance education, they also have the effect of excluding many individuals. Furthermore, the rapid evolution of these technologies complicates the adaptation of educational systems. Technology is often acquired without considering long-term costs, and teachers tend to adapt it to existing approaches, leading to unintended consequences (Williamson et al., 2024).

The accelerated implementation of ET during the COVID-19 pandemic, without sufficient preparation, has contributed to an exacerbation of the existing educational divide (Castañeda & Williamson, 2021). Research on ET must evolve to consider the interactions between technology, stakeholders, and educational contexts, as well as their ethical implications (Castañeda et al., 2020). In the 2020s, it is of paramount importance to address issues of social justice and to amplify the diversity of voices in educational research.

The learning environment is undergoing a transition towards smart education, which personalises learning, diversifies support and enhances the learning experience through ST and data. This is redefining the relationship between humans and machines in education (UNESCO IITE, COL, and BNU, 2022). Mollick and Mollick (2022) posit that AI chatbots, such as ChatGPT, can assist in overcoming significant and enduring obstacles to learning. They suggest that such bots can enhance knowledge transfer, dispel the illusion of profound comprehension, and instruct students in the critical evaluation of content. Furthermore, the authors put forth seven potential avenues for integrating AI into the

classroom, including its use as a tutor, coach, mentor, teammate, tool, simulator, and student, with each approach being tailored to the specific context and educational objectives (Mollick and Mollick, 2023). However, it is essential that teachers remain actively involved to ensure that students maintain a critical attitude towards AI. Current initiatives already use AI and virtual reality to personalise teaching (Hal Schwartz, 2024).

In the context of the post-digital era, it is imperative that the utilisation of technologies is instilled from an early age. While digital integration presents challenges, such as teacher digital literacy, it also offers significant benefits for learning, making it crucial to optimise its use in education (Awidi and Paynter, 2024).

## ***4.2. Regulation, Self-Regulation and Pedagogy: Technopedagogical Dodecalogue***

It is of the utmost importance to address the potential risks associated with the use of smart technologies through the implementation of proactive governance measures. It is incumbent upon states and international organisations to regulate these technologies through the enactment of legislation that ensures their safety, particularly with regard to minors. It is imperative that companies develop self-regulation mechanisms and conduct research to guarantee the secure, ethical, and effective utilisation of smart educational tools. This strategy will safeguard users' rights while enhancing the quality and accessibility of education.

Moreover, technology must be integrated with pedagogy to optimise learning outcomes and align with labour market demands. The subsequent section presents design considerations to minimise risks and recommendations for the effective use of technology in the classroom.

### ***4.2.1. Design Considerations for These Tools***

#### ***4.2.1.1. Fundamental Criterion of Humanity and Mandatory Participation of People***

AI tools in education should be human-centred and respect diversity (Miao and Holmes, 2024). It is essential to ethically validate their appropriateness before implementation, taking into account their long-term impact. Involving teachers and learners in co-design, allowing cultural and linguistic adaptation to ensure content relevance, adapting AI to different learning styles and supporting students with special needs are key suggestions.

#### ***4.2.1.2. Criteria for Protecting and Promoting the Self-Regulation of Minors***

In environments with minors, it is essential to involve other actors to ensure the appropriateness of AI tools and to create an environment that respects their privacy and allows them to make informed decisions about their data (Livingstone et al., 2022). Beyond parental control, a 'children's mode' has been proposed to promote self-regulation on platforms, alongside content protection and monitoring measures. This would involve minors in the design process, empower them to understand and manage their digital privacy, and promote shared responsibility between families, businesses and governments.

#### ***4.2.1.3. Criterion of Proactivity in Risk Assessment***

In the US, the Blueprint for an AI Bill of Rights (2022) and recent executive orders set out principles to protect citizens from AI risks such as discrimination and invasion of privacy (Executive Office of the President, 2023a, 2023b). These principles include key rights such as safety, anti-bias, privacy, and transparency in the use of AI. Although the National Artificial Intelligence Initiative Act (2020) suggests the need for regulation, current commitments are voluntary (The White House, 2023). Some states, such as California, are attempting to implement stricter laws, such as SB1047 (2024) and AB 3211 (2024), which require compliance with these commitments even in open-source AI.

In contrast, the EU has adopted stricter regulations, such as the AI Law (Regulation [EU] 2024/1689, 2024), which classifies AI systems into risk levels and prioritises data protection and privacy. It is imperative that the design of these tools facilitates the auditing and collection of anonymised data to investigate risks.

#### **4.2.1.4. Non-Discrimination and Assessment Criteria**

As in Spain (Law 15/2022, of 12 July, Comprehensive Law for Equal Treatment and Non-Discrimination, 2022) and the US (Executive Office of the President, 2023a), it is crucial to ensure that algorithms do not perpetuate discrimination, especially against vulnerable groups. Educational tools that use algorithms should include mechanisms to minimise bias and ensure transparency and accountability. These mechanisms should be built into both the design of the algorithms and the data used, addressing the risk of discrimination from the outset and allowing for impact assessments to identify potential shortcomings.

#### **4.2.1.5. Criteria for Early Integration of Ethics and Reversibility of Negative Effects in Design**

This criterion aims to ensure that AI tools in education are designed on a sound ethical basis and can quickly correct unintended negative effects, creating a safe and fair learning environment. It proposes the integration of ethical frameworks from the beginning of design to avoid ethics-washing and to ensure accountability and transparency (Hogenhout, 2021). Methodologies such as Ethics-by-Design and open-source tools such as LIME promote these principles. Reversibility in the design of educational AI allows for the identification and correction of negative consequences, promoting adaptive learning and prioritising the well-being of learners. In addition, integrated models that balance information in recommender systems can counteract epistemic bias (M. Wang et al., 2024).

#### **4.2.1.6. Non-Dependency Criterion**

This criterion establishes a crucial link between technological design and effective pedagogical practices. "Learning not to be dependent" on IT, while encouraging divergent thinking, is essential in intelligent education. The impact of AI on learners' autonomy and self-reliance must be countered, as many applications limit their independence and reinforce traditional approaches (Darvishi et al., 2024). While market pressures may limit creative learning, AI has the potential to support project-based learning experiences and learner interest, encouraging creativity and collaboration in a playful way (Resnick, 2024).

### **4.2.2. Recommendations for Conscious Work with These Tools in the Classroom**

Pedagogical innovation is key to the appropriate selection and integration of these tools into the classroom and must be accompanied by instructional design that takes into account students' needs and learning objectives. This requires teachers not only to be experts in their subject, but also to design content for active learning approaches (Awidi and Paynter, 2024). Teacher training and support are therefore essential steps in facilitating this innovation.

#### **4.2.2.1. Teacher Training, Anticipation and Interdisciplinarity**

Previous waves of technology have not anticipated teacher training, neither the appropriateness of tools to educational contexts, nor the impact on the interconnectedness of disciplines. It is essential to provide ongoing training programmes for teachers, teaching them not only how to use AI, but also how to understand its limitations, risks and safe pedagogical applications (Al-Zahrani, 2024). There is also a need for pilot testing to ensure that the tools respect ethical and pedagogical principles, and for the establishment of interdisciplinary committees to assess the impact of AI on the development of students' skills (Abbas et al., 2024).

#### **4.2.2.2. Prioritising the Development of (human) Creativity**

AI needs to be integrated into education in ways that enhance creativity (Habib et al., 2024), address students' concerns, and promote positive use of technology (Marrone et al., 2022). AI should guide learning, providing incremental hints rather than complete answers, and helping students learn from their mistakes (Bastani et al., 2024). The future of ET must balance AI assistance with strategies that encourage participation and autonomous learning (Darvishi et al., 2024). Teachers must promote a balanced relationship between human creativity and AI, preventing one from overshadowing the other (Habib et al., 2024).

#### ***4.2.2.3. Complementing and not Replacing the Teaching Staff***

AI in education should complement, not replace, teachers (Aparicio Gómez and Aparicio Gómez, 2024), respecting ethical principles and supporting the personalisation of learning without dehumanising it. This technology should enhance teaching without losing human interaction, while redefining the role of teachers as planners, coordinators and providers of educational services (Duan et al., 2023). AI can contribute to the development of teaching skills and promote a more dynamic and adaptive approach, with an emphasis on practical knowledge and multidisciplinary integration.

#### ***4.2.2.4. Developing Critical Thinking***

To mitigate the risks of AI in education, teachers must act as guides, teaching best practices and fostering a critical attitude towards AI outputs (Mollick and Mollick, 2022), complementing them with their own perspectives. It is essential that students actively participate in the evaluation of AI, which enhances their learning and develops their critical thinking and responsibility (Mollick and Mollick, 2023). Al-Zahrani (2024) suggests balancing AI with activities that promote critical thinking and creativity, suggesting measures such as encouraging divergent thinking, independent problem solving and critical analysis of AI-generated information.

#### ***4.2.2.5. Learning Environments for Autonomy, in Inter-Creative Collaboration.***

According to Castañeda et al. (2023), teachers should promote students' autonomy, allowing them to make decisions about their learning and to choose appropriate tools. This should take place in a collaborative environment where interaction between students enriches learning but promotes effective collaboration between human and non-human in the production of knowledge (Mañero, 2023). Teachers need to integrate technology in a reflective way, adapting it to individual needs and providing continuous feedback. It is also essential to regularly evaluate the impact of tools in the classroom in order to adapt pedagogical practices.

#### ***4.2.2.6. Language Remains the Main Key to Education.***

Language, thinking and communication are deeply interrelated and essential for cognitive development. In an ideal context where synthetic and human intelligences work together to form a new human identity, a language-based educational approach to the development of thinking and communication is essential. This approach allows not only to comprehend information, but also to create, transform, share and apply it, forming critical and reflective citizens capable of actively participating in a world with and without AI.

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