DOI: 10.25082/AMLER.2025.02.018

PERSPECTIVE

Artificial Intelligence and Virtual Reality in Learning Environments: Perspectives from Preschool to Higher Education

Sofia Kouloubritsidou

Department of Informatics Engineering, School of Engineering, Hellenic Mediterranean University, Heraklion, Crete, Greece

Correspondence to: Sofia Kouloubritsidou, Department of Informatics Engineering, School of Engineering, Hellenic Mediterranean University, Heraklion, Crete, Greece; Email: sofiakoul.tr@gmail.com

Received: June 30, 2025;
Accepted: October 22, 2025;
Published: November 3, 2025.

Citation: Kouloubritsidou, S. (2025). Artificial Intelligence and Virtual Reality in Learning Environments: Perspectives from Preschool to Higher Education. *Advances in Mobile Learning Educational Research*, 5(2), 1632-1652.
https://doi.org/10.25082/AMLER.2025.02.018

Abstract: We live in an era of the most accelerated technological changes. Artificial intelligence possesses immense power and has the potential to dramatically influence education, being considered an inevitable transformation. Additionally, another technology, virtual reality (VR), although still in its early stages, when combined with artificial intelligence (AI), has the potential to radically transform entertainment, education, and healthcare. Thus, there is a call for new approaches to an educational system increasingly permeated by artificial intelligence systems—models, standards, and learning assessments. However, significant challenges arise, raising issues of ethics and academic integrity, such as the reliability of information, transparency regarding the sources used, privacy and data security, and plagiarism, as well as the investigation of how artificial intelligence affects teaching. Experts in educational technology predict that in the future, new versions of these technologies will replace textbooks and take the learning process outside the classroom. Overall, the United States alone has over 10 million virtual reality systems, with the actual number likely significantly higher. Moreover, artificial intelligence will not only enable new technologies but will also analyze their effectiveness and optimize the benefits they can offer. This paper on the impact of virtual reality and artificial intelligence on the educational process represents a step in our efforts to understand how these technologies can transform the educational system. The research found that the nature of the content presented in virtual reality can change users' perspectives and behaviors, as well as develop their knowledge empirically through personalized simulations. Instead of hours in front of screens, imagine learning in just a few minutes through VR. Therefore, it seems that with virtual reality, a little is enough.

Keywords: Artificial Intelligence, Virtual Reality, metaverse, primary school, AI Act

1 Introduction

We are living in an era where education is being reshaped by rapid technological advancements. Artificial Intelligence (AI) and Virtual Reality (VR) are no longer abstract concepts or futuristic promises but active forces influencing how teaching and learning are conceived and practiced. Over the past decades, researchers have explored how AI can support curriculum design, teaching strategies, and assessment, while VR has emerged as a tool for immersive and experiential learning. Together, these technologies hold the potential to transform the classroom into an environment that is more interactive, adaptive, and inclusive.

At the same time, the integration of AI and VR raises important questions about access, ethics, and educational equity. Scholars emphasize both the promise and the risks: from improving learning outcomes and personalizing education, to concerns over privacy, bias, and the possible erosion of creativity and human agency (Papadakis, 2020, 2022). These debates encompass the entire educational spectrum, ranging from preschool robotics and conversational agents to higher education, professional training, and support for students with disabilities.

This article reviews current knowledge and emerging practices at the intersection of AI, VR, and education. It examines how these technologies are being applied in early childhood and higher education, their potential role in fostering inclusion for students with disabilities and dyslexia, and the ethical and political challenges they introduce. By drawing on international research and case studies, the discussion highlights both the opportunities and limitations of these tools.

The aim is twofold: first, to synthesize existing evidence on how AI and VR are shaping teaching and learning across various contexts; and second, to critically reflect on the pedagogical, social, and ethical implications of their use. In doing so, the article aims to contribute to ongoing debates about the future of education in an era where digital intelligence and immersive environments are becoming increasingly inseparable from the learning process.

2 Theoretical Background

2.1 Integrating Artificial Intelligence into Education

The first time artificial intelligence was mentioned was in 1950, when the question was posed, “Can machines think?” (Anyoha, 2017). Then, in 1956, during the Dartmouth conference led by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon, the birth of artificial intelligence as a field of study was documented. Over these 69 years, its development is evident today. Recently, there has been an increase in research on how artificial intelligence applications can be utilized to explore pedagogical opportunities throughout the student lifecycle (Zawacki-Richter et al., 2019), from curriculum development and teaching strategies to student assessment (Alzahrani, 2022; Chen et al., 2020; Zhu, 2021). As a result, a growing number of educational initiatives have been launched with the aim of teaching the fundamental principles of artificial intelligence to students in primary and secondary education (UNESCO, 2022).

For example, Rodríguez-García et al. (2020) designed a program called “LearningML” to teach students programming applications based on a subfield of artificial intelligence, namely machine learning. Wong et al. (2020) proposed a threedimensional framework for literacy in artificial intelligence, encompassing concepts such as machine learning, deep learning, and neural networks, as well as AI applications (e.g., speech recognition, robotics, and smart assistants), while also addressing the issue of ethics. Similarly, Lao (2020) proposed a Machine Learning (ML) Education Framework to highlight three categories of learning in artificial intelligence, including knowledge (e.g., general knowledge about ML methods, bias, and social impacts), skills (e.g., identifying the scope of ML problem applications, designing ML projects, creating ML artifacts), and attitudes (interest, self-efficacy, persistence, and identity).

However, for individuals to acquire literate knowledge in artificial intelligence, it is essential to provide them with basic knowledge and skills related to AI, starting from preschool education (Papadakis et al., 2023a, 2023b). Preschool education possesses unique characteristics that facilitate the development of essential skills for daily life, the acquisition of knowledge through play, and the fundamental competencies that will be crucial for future classes (Li & Chen, 2023). Additionally, research on preschool education indicates that artificial intelligence can be beneficial and useful for children’s development (Chen & Lin, 2024). It is already known that the implementation of artificial intelligence activities from kindergarten and after promotes the development of computational thinking and problem-solving skills (Fauzi et al., 2023; Williams et al., 2019). Therefore, it is crucial for children to acquire the basic knowledge and skills related to artificial intelligence from a young age, to ensure a solid foundation in this field (Betül-Kölemen & Yıldırım, 2025) and to understand the role that artificial intelligence plays in society, recognizing that artificial intelligence is learned through interactions with other people (Tazume et al., 2020).

Other studies have shown that the use of robots in the preschool period enhances children’s literacy skills (Kewalramani et al., 2021). Children can be exposed to technologies that simulate human communication by observing robots in environments where they interact and learn from humans. Smart robots can enhance children’s social interactions, leading to increased participation in activities and collaboration with other students (Druga et al., 2019; Kewalramani et al., 2021). For example, AI-based conversational robots such as KIBO, LEGO, PopBots, and Zhorai can enhance student engagement and help them understand the concepts of artificial intelligence and machine learning (Lin et al., 2020; Williams et al., 2019).

Moreover, various robots, such as NAO, KASPAR, AIBO, and RuBI, are used in preschool education. Specifically, AIBO, developed by Sony, can increase children’s excitement in the learning process and provide an engaging learning experience. RuBI is designed for interpersonal communication and is used in preschool education to help children develop social interaction skills (Johnson et al., 2012). In Japan, a robot called Saya is already used in classrooms to perform disciplinary tasks. Saya can speak many languages, and a series of motors in its head can stretch the soft synthetic skin, allowing it to display a variety of emotions on its “face,” from happiness and surprise to sadness and anger. The robot is capable of simulating various emotions and can also read books, tell stories to children, answer specific questions, and engage in conversation with them. Furthermore, in Thailand, teaching robots are used to motivate students. Consequently, the combination of robotics and artificial intelligence can create technologies designed to support education (Annus, 2024).

However, the use of smart chatbots, like other technologies, has both advantages and disadvantages, as it can hinder the development of students' creativity, expressive skills, and vocabulary (Annus, 2024). Therefore, to disseminate artificial intelligence literacy and promote it in education, and subsequently in today's and future workforces, it is essential to focus on the conceptual understanding of artificial intelligence. This is essential for fostering active citizen participation and for developing and enhancing diverse workforce capabilities, rather than simply focusing on complex programming and mathematical skills (Kong et al., 2021, 2022). The truth is that there is a significant gap between the skills taught in schools and those required in the workplace and society in the age of AI (UNESCO, 2022). To prepare the global workforce for the transition from the information society to the artificial intelligence society, the United Nations Educational, Scientific and Cultural Organization (UNESCO) established a global framework in 2018 to help define and measure digital literacy. The framework encompasses seven competency areas, each related to a distinct domain: software, data, and communication.

Such an initiative requires educators to create an open, flexible, forward-thinking, and innovative educational environment that promotes quality education and ensures equal access to it (Storey & Wagner, 2024). However, establishing this new path is challenging, as it requires educators to possess the necessary knowledge and skills (Zourmpakis et al., 2023a, 2023b). That is why it is essential for all educators to continue learning and adapting to overcome obstacles, effectively integrating artificial intelligence into plans for future development (Kaliisa et al., 2022). Today, virtual teaching assistants can assume responsibilities such as creating individual and group learning activities, distributing and collecting assignments, addressing repetitive questions, and providing personalized feedback on projects (Kang, 2023). Specifically, Computer-Assisted Instruction (CAI) for distance adult education is an early example of artificial intelligence (AI) applied in education (Storey & Wagner, 2024).

2.2 Artificial Intelligence in Higher Education

The productivity of educational activities has significantly improved since the use of artificial intelligence. Globally, particularly in education, the proportion of students relying on machines and automated systems instead of humans is steadily increasing. The benefit is that, when properly implemented, these technologies in higher education enhance opportunities for research, learning, and teaching (Kulieshov, 2022). Kaliuzhna (2023) has developed methods based on artificial intelligence and neural networks that support the development of critical thinking through personalization, combined with comprehensive access to databases and adaptive learning environments, which have great potential for improving teaching in higher education. Also, game-based education (in a fun format) can motivate students to take educational tests, perform creative tasks, navigate study material more effectively, and understand complex subjects. Today, artificial intelligence systems open new opportunities for teaching in higher education, but they still cannot fully replace teachers. However, the rapid development of artificial intelligence, information, and communication technologies in the field of education may eventually lead to the replacement of humans as educators (Ryzheva et al., 2024).

In reality, the traditional teaching methods of higher education institutions have lost their effectiveness and no longer meet modern needs. New methods and new ideas regarding the digital transformation of higher education institutions are now essential. These approaches will enable the integration of all software creation and usage processes for the development of a digital university. Consequently, there is an urgent scientific task to develop methods and models for the digitalization of institutions based on artificial intelligence. The purpose of artificial intelligence in education is to enhance the educational process and increase human intelligence, because education is not a technology-oriented solution but an exclusively human-centered activity. Therefore, education requires a restructuring of the mindset of both students and teachers (Ryzheva et al., 2024). Borysenko (2023) paid special attention to the creation of a customized digital platform that combines artificial intelligence and virtual reality for the in-depth professional education of specialists.

For university students, the way information is presented does not matter as much as ensuring it does not become a dead dogma. As a result, educators recommend using games as a means to develop critical thinking and facilitate the learning of essential economic and educational knowledge (Ryzheva et al., 2024). However, scholars argue that education is a form of educational process that does not rely solely on the mechanism of entertainment, but also includes additional processes. These processes are considered of utmost importance (Stratan-Artyshkova et al., 2022). For example, entertainment is only the first step. The ultimate goal of the educational process is for the student to develop a passion for the subject and to continue enjoying education (Aksakal, 2015). As a result, for a superior educational process that enhances visualization and learning effectiveness, a new direction has emerged in the development of artificial intelligence, which includes virtual reality. The application of virtual reality in a new educational environment that involves more than just reading and writing makes each task unique, bringing the educational process as close to reality as possible, both visually and procedurally (Ryzheva et al., 2024).

In conclusion, virtual reality can address the challenges faced by teachers and students in traditional teaching methods, such as conducting practical experiments in classrooms, where acquiring in-depth knowledge and understanding is crucial. Some experiments are hazardous and pose multiple environmental and safety concerns. Even if a teacher is present in such critical situations, it is not possible to give each student enough attention and time, which leads to further frustration, negative emotions, and dissatisfaction among students. With these feelings, students cannot learn theoretical knowledge nor make progress in their experience. However, virtual reality has the potential to enhance the learning process in a meaningful way by adding value to interactions and participation. Examples of educational uses implemented in educational institutions include room-scale virtual reality, such as the CAVE, standalone virtual reality, such as the Oculus Rift and HTC Vive, and mobile virtual reality, such as Samsung's Gear VR and Google Cardboard (Ahmad et al., 2022).

However, new technologies play an auxiliary role. Only university professors can create a culture that inspires and motivates students. The difference between a virtual teacher and an avatar is that the avatar is the "representative" of the teacher during the lesson,while the virtual teacher is presented in virtual form while narrating the material in video format. Additionally, creating a teacher avatar involves many stages and is a complex process (Ryzheva et al., 2024).

2.3 The Impact of Artificial Intelligence on Political Science Education

Recent applications of new innovations in the field of artificial intelligence (AI) have raised questions about how this new technology will change the scenery and $\tau\eta\epsilon$ practices applied across all sectors and fields. The main arguments concern the extent to which LLMs (Large Language Models) are considered plagiarism, the impact these tools would have on students' learning and career preparation, and whether the use of AI tools should be explicitly prohibited, integrated, or encouraged. These philosophical differences are reflected in university statements. For example, the Harvard Law School Statement on the use of AI language models states that "the use of artificial intelligence for preparing academic work for a course is prohibited unless the instructor identifies it as an appropriate source." In contrast, the Sandra Day O'Connor College of Law at Arizona State University allows applicants to use generative AI, mentioning its prevalence in the legal field and the school's mission "to educate and prepare the next generation of lawyers and leaders." Princeton University states that it does not intend to prohibit or impose a specific approach for each instructor to handle AI programs (Wu & Wu, 2024).

Additionally, educators in political science believe that political science is a cognitively demanding profession and support the use of artificial intelligence in an assistive, rather than generative, manner. Most recognize the value of AI-based tools but are hesitant to incorporate them into the classroom. Furthermore, a large proportion stated that they are extremely likely to use AI detection systems. Tools such as GPTZero claim to be able to accurately distinguish between artificial intelligence-generated work and human-written work (Wu & Wu, 2024). However, case studies have shown that these tools have a false positive rate (Benj, 2023; Fowler, 2023). A student who is falsely accused of cheating will face long-term consequences (Wu & Wu, 2024). Finally, OpenAI released an AI detector intended to identify AI-generated written work, but quietly discontinued the software after only eight months due to low accuracy (Kirchner et al., 2023). Let us not forget that additions to problematic detection methods may lead to increased anxiety and burden for all parties involved (Wu & Wu, 2024).

In short, educators who wish to ban the use of artificial intelligence technologies may not have the ability to do so, because there is no reliable way to detect them. Those who wish to minimize students' exposure to artificial intelligence should propose alternative activities that foster creativity and critical thinking before implementing LLMs. These activities serve an additional purpose today (Wu & Wu, 2024). Educational innovations and interventions, including group concept mapping (Wilson et al., 2023) and reflection on classroom simulations and games (Handby, 2021), do not favor outcomes generated by artificial intelligence. As a result, students may be less inclined to use artificial intelligence to complete these assignments.

Consequently, as artificial intelligence technologies become more pervasive in the workplace and society, our discipline will benefit from ongoing discussions about the opportunities and pitfalls of AI tools in higher education (Wu & Wu, 2024).

Moreover, between April and August 2023, two surveys were conducted in parallel with the APSA to better understand how political scientists perceive the value and significance of generative LLMs. The studies show a mix of skepticism, uncertainty, and recognition of the potential impact of artificial intelligence on teaching and learning. All respondents stated that improving writing skills and generating original arguments are among the most important pedagogical objectives of written assignments. Common themes included critical and analytical thinking, understanding of material, knowledge synthesis, concept evaluation, and the development of professional skills. However, educators were generally more cautious than optimistic about the use of artificial intelligence technology. These findings are not unexpected, given the current state and anticipated capabilities of these tools, and how they could negatively impact educators' ability to achieve important goals through the written assignments they assign to their students (Wu & Wu, 2024).

2.4 The Impact of Artificial Intelligence and Virtual Reality on the Education of People with Disabilities

The Convention on the Rights of Persons with Disabilities (CRPD), adopted by the United Nations General Assembly in 2006, represents a significant milestone in global efforts to recognize and protect the rights of persons with disabilities. The convention emphasizes co-education and requires the removal of barriers through changes in the educational system so that all students, regardless of their disabilities, can receive equal education. The CRPD, along with the International Classification of Functioning, Disability and Health (ICFDH), advocates for a comprehensive revision of educational practices, requiring modifications in content, teaching methods, and institutional structures to address the diverse needs of students with disabilities. In this context, promising methods are being developed to enhance educational participation through the use of emerging technologies such as AI and VR (Chalkiadakis et al., 2024).

The use of artificial intelligence enables teachers and educators to tailor the content of teaching materials and their methods to students' individual learning preferences, needs, and desires. At the same time, virtual reality can serve as a vehicle for more interactive and experiential learning. In this way, the conduct of teaching changes, allowing all students to have a more equitable experience in the classroom, regardless of their abilities or disabilities. Specifically, artificial intelligence can be defined as an adaptive learning platform that alters content based on student performance. For example, DreamBox, a mathematics teaching tool, continuously adjusts lessons according to users' responses. Moreover, virtual reality is utilized in platforms like Labster, where students can conduct scientific experiments virtually, thereby overcoming the physical limitations of traditional learning. This is important for bridging the existing gaps between theory and practice (Chalkiadakis et al., 2024).

In this way, students with disabilities can address some of the physical, social, and cognitive issues that have historically prevented their participation in learning processes. As a result, AI and VR systems play a significant role in enhancing the academic success of students with disabilities. They also foster a sense of belonging through interaction among diverse student groups, ultimately leading to the creation of an inclusive society where respect and understanding are paramount. However, despite government initiatives and strategies to promote inclusive education, they have not yet had a significant impact or capacity to ensure equal access and opportunities for all individuals. The lack of students with disabilities in educational programs directly affects both themselves and their peers in multiple ways. The first ones do not have access to the tools and materials necessary for their personal development and academic success, while the latter do not have the opportunity to learn and grow in a diverse environment, which is essential for fostering a society with greater empathy, understanding, and acceptance (Chalkiadakis et al., 2024).

2.5 Virtual Reality in Education

Virtual reality was initially intended for marketing purposes, primarily for gaming. However, various fields can benefit from virtual reality (VR) applications, such as medicine, sports, tourism, music, driving simulation, media, and education. Regarding the latter, VR has seen significant growth in popularity in the field of education in recent years (Zourmpakis et al., 2024). Virtual platforms are commonly used to simulate the classroom or laboratory environment where lessons take place. However, some of these simulations are typically used as a safe environment for testing scenarios that would be too difficult or dangerous for people to operate in the real world. Yet, the most important advantage of VR is that it allows users to immerse themselves in the virtual world and then transfer to the real world, where they can appropriately handle almost any situation. For example, students can walk on Mars or travel inside the human body through blood cells (Atta et al., 2023).

Furthermore, virtual reality can enhance students' attention by keeping them focused within the VR environment. Teenagers often struggle to pay attention in class, especially when the topics are not related to them. Immersing students in a virtual world can therefore increase their interest and engagement in the learning process. They can also focus better on lesson material when wearing VR headsets, as visual and auditory distractions are eliminated. As a result, by using virtual reality methods, teachers will have increased opportunities for direct one-on-one interaction with students. For the students themselves, these experiences enable them to explore solutions to real-world problems and collaborate with one another for this purpose. In this way, the immersive element of virtual reality helps develop empathy for the subject being experienced. It also provides them with a clearer understanding and visual representation of their tasks, enabling them to complete them with greater accuracy and interest. Multiple studies and reports have shown that most students remember what they experience in VR, leading to the conclusion that this environment is more memorable than traditional educational techniques (Atta et al., 2023).

It has been demonstrated that virtual reality can enhance spatial and depth understanding among students aged 12–15. This also facilitates students' ability to visualize and handle objects, enabling them to understand difficult concepts more easily. As a consequence, Mintz et al. (2001) provided a new interactive three-dimensional model of the solar system in VR, which simulates the physical world for students. Welsh and Windmuller (2020) used VR technology to introduce the concept of introductory astronomy, and in several studies, other researchers used VR to simulate the solar system. The created virtual world continues to function as the real world, while the viewer magnifies or reduces the created virtual world and changes their perspective. Whether computer-generated or based on 360-degree video, interactive virtual experiences offer students a unique experience without the difficulties of the real world (Atta et al., 2023). Through 360- degree video, students can observe scenes from any viewpoint they choose, allowing them to explore virtual worlds by viewing scenes from any angle. As a result, 360-degree content creates an immersive experience that resembles a live broadcast more closely than a traditional video. Additionally, since the contents of the panorama are projected onto a spherical surface as a single plane, viewers can observe the panorama by simply turning their heads without physically participating in the action (Atta et al., 2023).

2.6 Forms of Learning in the Digital Age

There are various stages of evolution in the traditional teaching system. First, the blackboard has been replaced by projectors and other digital media devices to facilitate a better understanding of concepts through the use of visualizations. Second, students now visit computer labs at schools more than ever before. And third, online courses have become a reality. Thus, in this digital age, the method of teaching is shifting to e-learning (Chelloug et al., 2023). According to Kotsilieris et al. (2013), the application of the virtual world in e-learning can change the way people interact with each other. As a result, "artificial intelligence" is no longer a term used by scientists. Instead, they prefer the term "augmented intelligence". Nevertheless, this description still maintains that the human brain is the center of true intelligence (Annus, 2024).

The truth is that we live in a world where it is increasingly difficult to distinguish between a real person and a virtual entity (Papadakis et al., 2024). Kokane et al. (2014) developed a system based on a 3D virtual teacher using the WebRTC (Web Real-Time Communications) application for e-learning. Webb et al. (2022) simulated nanoscale cells in 3D, which can help biology students understand concepts more deeply and visualize them more effectively than traditional 2D diagrams. Schönborn et al. (2011) investigated the use of tactile virtual models by higher education students to understand the structure of biomolecular connections, where tactile materials were used in conjunction with their virtual representations for model rendering. Through the use of this system, structures can be easily visualized and interacted with using touch sensors. Previously, there was a problem in this field where we could only visualize the model but not interact with it. Grajewski et al. (2015) addressed this problem by using touch sensors and virtual reality. Also, according to Edwards et al. (2019), tactile virtual reality is beneficial for the field of organic chemistry due to its ability to promote a sense of immersion.

In this way, the use of virtual reality (VR) can facilitate a comprehensive understanding of any possible concept, enhance interaction between students and instructors, and bridge the gap between the learning management system (LMS) and learning theories (Chelloug et al., 2023). However, in the field of image and video analysis for virtual reality applications, current methods are often suboptimal, primarily due to two significant factors. First, the data used for training and testing these models consists mainly of images and videos, which inherently contain various types of noise that degrade data quality. Second, many existing approaches have used classical methods that lack the complex patterns necessary for advanced VR applications. This highlights the necessity for learning strategies that involve multiple learning algorithms to produce more accurate results and significantly improve performance through a more detailed understanding and utilization of the natural features of individuals interacting with each other in VR environments (Raza et al., 2024).

Using machine learning algorithms, researchers attempted to collect and analyze various behavioral signals in order to determine the extent to which individuals experience virtual reality as immersive (Wu & Han, 2023). These methods encompass a range of approaches, including computer vision, natural language processing, and sensor data analysis. Computer vision technology enables the monitoring and analysis of movements, expressions, and gaze patterns, providing valuable insights into user engagement and presence in virtual environments (Ahuja et al., 2023).

2.7 Extended Reality (XR): Virtual Reality, Augmented Reality and Mixed Reality

Improvements in computational power have led to significant progress in virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies. Recently, the term XR (Extended Reality) technology, which broadly encompasses VR/AR/MR technologies, has become the focus of attention. VR is “an immersive, fully artificial environment simulated by computers with real-time interactivity” and is most commonly used in medical education. AR is described as “the concept of digitally overlaying virtual objects onto real space, allowing people to interact with them simultaneously.” In practice, computer-generated images are placed over real-world images and displayed on the screen. On the other hand, MR, as a hybrid of AR and VR, is the result of merging the physical and digital worlds. It has attracted significant attention in recent years, as it can moderate the limitations of virtual reality, which excludes the real environment, and the inability of AR to interact with three-dimensional (3D) data sets. Ultimately, VR and MR are primarily used in educational and preparatory roles, whereas AR is mainly applied in surgical settings (Morimoto et al., 2022).

From 1992 to 2020, the most popular research topics were diagnostic procedures, surgical interventions, and rehabilitation. Numerous studies have demonstrated the value of XR technology in medical education, due to ethical concerns related to the use of cadavers, as well as the time, cost, and availability of such bodies for training. However, three-dimensional holograms, which originate from XR technology, can effectively enhance the quality of education by improving intuitive understanding and spatial awareness through stereoscopic vision. There are increasing reports of hologram-based surgical navigation, which aims to improve existing surgical procedures by reconstructing the patient’s anatomy in 3D form and placing it in the surgeon’s field of view. For example, Elmi-Terander et al. (2019) developed augmented reality surgical navigation (ARSN) for screw placement in a hybrid XR operating room (Morimoto et al., 2022).

As a result, the use of XR technology can facilitate faster understanding of surgical anatomy, reduce the learning curve, positively impact the accuracy and safety of surgical procedures, and increase patient satisfaction. Specifically, Mcknight et al. (2020) argued that remote surgical guidance from an experienced surgeon using an iPad or Google Glass HMD (HoloLens 2) as a display is beneficial for both beginner and experienced surgeons when learning a new procedure, such as shoulder arthroscopy or shoulder arthroplasty. Furthermore, when instructors wore HMDs to teach medical students at a London-based teaching hospital, they conducted educational activities via remote access that were highly successful. In medical education, the HMD can provide students with remote training that was previously unattainable. However, HMD visualization faces the challenge of distraction when the surgeon looks away from the surgical field to observe the screen (Morimoto et al., 2022).

2.8 Artificial Intelligence in Education Around the World

As the ongoing discussion about integrating artificial intelligence (AI) into formal educational systems progresses, it is essential to consider both the curriculum and teaching methods, particularly in developing countries. Due to the need for students to acquire essential skills for their future, countries around the world have modified their educational programs. This move aligns with the growing interest in AI education for all students from kindergarten through high school. For example, Gardner-McCune et al. (2022) collaborated with teachers in the United States to create a curriculum that incorporates artificial intelligence. Similarly, Chiu et al. (2024) documented that their curriculum, designed in collaboration with researchers and teachers for AI learning, was implemented in schools in Hong Kong (Deriba & Sanusi, 2025). Additionally, a 2022 UNESCO report documented the implementation of AI-based curricula, showing that some countries in Europe and the Americas have begun incorporating AI education into schools. However, such programs have not been established in Africa.

To educate students about artificial intelligence, researchers and teachers have developed various models. Some of the identified frameworks include: 1) Five Big Ideas in AI (Touretzky et al., 2019) and 2) AI Competencies and Design Considerations Framework (Long & Magerko, 2020), 3) Machine Learning Education Framework (Lao, 2020), 4) AI Literacy and Competency Frameworks (Chiu et al., 2024). These frameworks have been adopted or modified worldwide to create AI-based learning experiences for students from kindergarten to high school. In Ethiopia, computer science has been integrated into the core educational system (Kassa & Mekonnen, 2022), with the subject introduced through the Information and Communication Technologies (ICT) curriculum, which spans grades 1 to 12. However, there are differences between public and private schools regarding the implementation of ICT education, especially in the lower grades. In public schools, a formal ICT curriculum begins only in grade 7 (Deriba & Sanusi, 2025).

In addition, while studies continue to explore how to integrate artificial intelligence into school systems, researcherdesigned curricula are mainly implemented as extracurricular activities rather than as part of the formal curriculum (Deriba & Sanusi, 2025). However, preschool teachers have begun to take significant steps toward integrating digital technology into their daily tasks (Dwyer et al., 2019). Also, the use of digital technologies has facilitated communication among students, children's collaboration and communication with their parents, and the recording of their learning (James & Henry, 2017; McFaddden & Tomas, 2016; Parnell & Bartlett, 2012). For this reason, researchers in Hong Kong have begun to focus more on AI-based education for young children, as evident in recent publications (Su & Yang, 2022; Yang, 2022). Finally, Caucheteux et al. (2024) observed that high school students in France are increasingly aware of the social implications of artificial intelligence and have shown a lasting enthusiasm for technology that extends beyond traditional academic frameworks.

Regarding the main cases of AI education conducted by governments or private sectors around the world, they include: 1) the "AI for ALL" program in the United States (which emphasizes that AI education should be open to all, solve social problems, and provide free educational platforms), 2) the "Artificial Intelligence in the United Kingdom" report (which states that the ethical use of AI technologies should be an integral part of the curriculum), 3) a free online course developed by Finland for basic AI education (called "Elements of AI"), 4) the "AI Experiment Manual" for toddlers to college students (which has been developed and implemented in China since 2019), and 5) the 2022 school program, which South Korea has enhanced and revised for AI education and the basic principles of its ethical use (Paek & Kim, 2021).

According to Chen et al. (2020), artificial intelligence has been widely applied in the educational sector in many ways at every level. Chatterjee and Bhattacharjee (2020) studied the factors influencing the adoption of artificial intelligence in higher education in India using the Unified Theory of Acceptance and Use of Technology (UTAUT), and found that factors such as perceived risk (PR), expected effort (EE), facilitating conditions (FC), and behavioral intention (BI) have a significant impact on the adoption of AI in higher education. Moreover, based on the recommendations of the National Education Policy 2020, the Central Board of Secondary Education (CBSE) in India has integrated artificial intelligence into school education since the academic year 2019-20 (Karan & Angadi, 2023). Additionally, von Garrel and Mayer (2023) observed that higher education students across Germany are using generative artificial intelligence (such as ChatGPT) in STEM fields, and the adoption rate has increased, which may be due to their inherent inclination toward artificial intelligence.

2.9 Exploring Issues and Needs of Dyslexic Students at University

The World Health Organization (WHO) classifies specific learning disorders (SLDs) as neurodevelopmental disorders that have a significant and long-term impact on learning abilities.

Specific learning disorders affect a significant portion of the population. Overall, 80% of cases are related to dyslexia, which causes significant problems in acquiring skills related to reading, memorization, and presenting ideas. While extensive efforts have been made to recognize dyslexia and mitigate its effects in both primary and secondary education, little progress has been made at the university level. The VRAIlexia project was created to address this problem, aiming to create and promote an innovative teaching method intended for all students with dyslexia. At the core is the BESPECIAL project, a software platform based on artificial intelligence and virtual reality designed to address the main issues related to dyslexia and provide students with tailored digital support methods to facilitate their academic challenges (Zingoni et al., 2021).

Several studies have explored the potential use of artificial intelligence, suggesting that it could be one of the most effective means of addressing this issue. The ability of artificial intelligence to recognize future events based on the data it receives makes it a powerful platform for analyzing large volumes of information. Furthermore, improvements over the years have led to highly effective techniques capable of processing many different data types simultaneously. The truth is that only personalized models are capable of accurately identifying students with dyslexia and providing them with effective assistance. For example, the Hidden Markov Model predicted the difficulties that elementary school students with dyslexia would have in learning Malay by monitoring their errors in solving phonetic, spelling, reading, and writing exercises. Using a similar approach, a computer-assisted learning system based on failure prediction was developed, resulting in a 60% improvement in student skills outcomes compared to traditional support tools (Zingoni et al., 2021).

2.10 AIED Systems and Pedagogical Literacy

The key to determining the impact of artificial intelligence in the field of education lies in a system capable of applying artificial intelligence for education (AIED). Holmes et al. (2016) have generally described AIED as consisting of three parts: the first is the use of an Intelligent Tutoring System (ITS), which determines the optimal learning path for a specific domain of knowledge, such as mathematics or physics. A representative AIED system utilizing ITS is MATHia at Carnegie Mellon University (Paek & Kim, 2021). The second is the use of a "Dialogue-Based Tutoring System (DBTS)," which employs advanced natural language processing and natural language generation technologies to guide students in engaging in learning dialogues. Programs such as "Fractions Lab" and "Betty's Brain" serve as characteristic examples (Paek & Kim, 2021). The third is the utilization of an Exploratory Learning Environment (ELE). Exploratory learning environments have an embedded mechanism that corrects students' erroneous learning outcomes using a more constructive approach. In short, they encourage students to actively construct knowledge by exploring elements of the learning environment, instead of following a predetermined, step-by-step learning process.

However, while the list of references on artificial intelligence literacy is extensive in colleges, universities, and research settings (Su et al., 2022; Su et al., 2023), little attention has been given to young children between 3 and 5 years old (Su et al., 2023). Furthermore, the average level of artificial intelligence knowledge expected from students in preschool, primary, and secondary education is significantly different (Su et al., 2022). While young children are expected to be familiar with the basic concepts of artificial intelligence (Su & Zhong, 2022), elementary and secondary school children are required to have a greater understanding of complex artificial intelligence knowledge, including the ability to create machine learning models (Shamir & Levin, 2022; Su et al., 2022). Therefore, to enable children growing up in the age of artificial intelligence to encounter the changing technological environment, three artificial intelligence curricula were developed for secondary school: Creative AI, Dancing with AI, and How to Train Your Robot (Williams et al., 2023).

These specific curricula aim to promote active learning through practical activities and projects and to integrate ethics and critical reflection on the social impact of artificial intelligence across all disciplines. The three curricula included concepts and technologies related to artificial intelligence, such as Generative Adversarial Networks (GANs), effective perception, and autonomous robotics (Williams et al., 2023). Specifically, in Creative AI, students are exposed to various types of AIgenerated media and are encouraged to consider the social consequences of GANs, such as the creation of deepfakes and the spread of misinformation through social media used by students (Ali et al., 2021a; DiPaola et al., 2021). In Dancing with AI, students are introduced to a variety of block-based coding tools powered by AI (Jordan et al., 2021). In these courses, students design and build interactive, movement-based multimedia games. Also, in the course "How to Train Your Robot," a low-cost Bluetooth robot is integrated into the machine learning curriculum, enabling students to create artificial intelligence projects motivated by social contribution. Finally, as students studied the technical aspects of concepts in conjunction with ethical considerations, they developed a critical perspective to understand how AI systems work and their impact on society (Williams et al., 2023).

Other research has shown that learning artificial intelligence in kindergarten can have a positive impact on young children's basic knowledge and inquiry skills in artificial intelligence (Kewalramani et al., 2021; Lin et al., 2020; Williams et al. 2019; Williams et al., 2019). For example, improvements in artificial intelligence literacy (Williams et al., 2019) and investigative skills (Kewalramani et al., 2021) have been observed in young children who participated in artificial intelligence classes. Additionally, as demonstrated by Kandlhofer et al. (2016), learning methods that combine discovery and investigation with storytelling activities can effectively teach kindergarten students the basic concepts of artificial intelligence. Finally, Yang (2022) proposed a model using intelligent agents (such as AI for Oceans, Teachable Machine, and Quick, Draw!) to enable children to learn artificial intelligence.

2.11 The Ethics of Artificial Intelligence

Despite the fact that young people are growing up in an environment already permeated with artificial intelligence technologies such as SIRI and Alexa (Su & Yang, 2022; Van Brummelen et al., 2021), there is a worrying lack of understanding regarding the fundamental principles and processes of artificial intelligence (Ali et al., 2019). The lack of awareness about the accuracy of AI data (Mertala et al., 2022) and the emergence of deepfakes (McNicholas, 2023) have led to discussions about the ethical nature of artificial intelligence (Crawford, 2021) and its implications for privacy and security (Floridi, 2018). That is why addressing this deficiency is of utmost importance for young students, enabling them to develop a conceptual understanding of artificial intelligence (Mertala et al., 2022; Rodríguez-García et al., 2021). This is because collaboration between humans and AI is only possible when people use artificial intelligence correctly and confidently to solve problems (Kong et al., 2024). Therefore, ethical guidelines for the development and operation of artificial intelligence systems should align with social values (Nguyen et al., 2023).

Understanding how to use artificial intelligence in an ethical manner enables students to critically evaluate and analyze AI developments and to co-form society's response in the age of AI (Kong et al., 2024). However, as with all technological advancements, there are both positive and negative impacts. Balancing these impacts when using artificial intelligence is a responsibility for students who have been trained in AI, as they must consider the ethical implications when addressing various issues. The rationale for doing this is twofold: 1. To ensure that AI-related solutions deliver net benefits to society. 2. To ensure that the widespread use of artificial intelligence is sustainable and aligned with the Sustainable Development Goals (SDGs) (Vinuesa et al., 2020). Most people are often unaware that they are interacting with algorithms that may compromise their privacy or contain harmful biases against various demographic groups (Williams et al., 2023).

However, it is also necessary to investigate ethical behavior from the perspective of machines themselves and to examine the decisions and actions taken autonomously by machines (Müller, 2020). The ability to interpret AI decisions enables the assessment of whether a decision aligns with ethical standards (Yu & Yu, 2023). It is true that the behavior of artificial intelligence systems depends on the environment in which they operate, and if not expressed accurately, they may produce unsatisfactory or even erroneous solutions. And since artificial intelligence itself lacks sufficient reliability and does not possess the so-called "moral compass," the use of AI itself should be ethical (Wojciechowski & Korjonen-Kuusipuro, 2023). Therefore, by combining the opportunities and challenges of AI applications, people should effectively control artificial intelligence while promoting social development. In this way, people can achieve a balance between the development of AI technology and the construction of social harmony (Yu & Yu, 2023).

Law, a positive science that encompasses rules and principles designed to regulate current situations, should provide the necessary framework for addressing concerns about ethical issues in society (Kölemen, 2024). If AI technology underestimates human skills, removes responsibility from people, weakens human control, or undermines human autonomy, it may become subject to misuse (Yu & Yu, 2023). For example, in relation to student assessment systems, it has been found that they produce inaccurate outcomes based on factors such as gender, ethnicity, or socioeconomic status (Kölemen, 2024). This is particularly damaging in countries where primary education does not focus on teamwork and empathy.

The CEO of OpenAI, Sam Altman, also followed the same pattern when he described ChatGPT as "extremely limited, but good enough at some things to create a misleading impression of greatness. It would be a mistake to rely on it for anything important at this time. It is just a preview of progress. We still have a lot of work to do on robustness and truthfulness" (Wojciechowski & Korjonen-Kuusipuro, 2023). For example, if a child expresses self-doubt, a chatbot trained to confirm user statements may respond in a general manner, reinforcing the child's negative self-perceptions instead of providing constructive support. This would endanger the child's health, increasing the likelihood of mental disorders such as anxiety or depression (Kurian, 2023). Research on children's interactions with computers shows that even very young children engage with technology in ways that may surprise adults.

One report found that nearly half of the 3,000 six-year-olds surveyed in the United Kingdom browsed the internet unsupervised for hours at a time (Internet Matters Team, 2017). While EU lawmakers have already discussed the Commission's proposal on the desired and appropriate regulation of artificial intelligence on April 21, 2021, as Regulation (EU) 2024/1689 (Veale & Borgesius, 2021; Gstrein, 2022), the growing popularity of generative AI has sparked a debate on whether specific laws are required (Hacker et al., 2023; Helberger & Diakopoulos, 2023) or even legally binding international treaties (Harris, 2023; Milmo & Stacey, 2023).

In Greece, the Panhellenic Federation of Journalists' Unions (POESY) published the Code of Ethics Guidelines for the use of artificial intelligence by journalists. The guidelines aim to guide journalists in the responsible and ethical use of creative artificial intelligence. The goal is to ensure that AI is used as a tool to enhance the accuracy, objectivity, and reliability of news without compromising fundamental principles. Journalists using creative AI tools must prioritize the public interest, maintain public trust, and ensure their work is verified. AI was not created to replace journalists and their role in providing information to citizens. The content of any form generated by AI should be regarded by journalists as unverified and must be checked and cross-verified (Journalists' Union, 2025).

2.12 Research Analyses on Artificial Intelligence in Education

Most studies have revealed that the use of artificial intelligence can enhance creativity, collaborative research (Kewalramani et al., 2021), computational thinking, and language skills in children (Prentzas, 2013). The following study used the case study research methodology (Yin, 2014) to describe the complexity of change processes related to the implementation of an AI curriculum called "AI4Kids" in a purposefully selected kindergarten in Hong Kong, using the theory of multimodal learning (Yelland, 2018) and the Five Big Ideas in Artificial Intelligence (Touretzky et al., 2019) as criteria for evaluating learning outcomes. The aim is to enhance learning through artificial intelligence by incorporating embedded learning activities and intelligent agents, such as AI for Oceans, Teachable Machine, and Clearot. Children worked in pairs using iPads to train an AI robot. The educator utilized project-based learning to motivate children's autonomy in learning about artificial intelligence through real-world applications. The research results indicate that children can understand artificial intelligence through interaction with intelligent agents in the practical application of the learning process. Additionally, the children learned that computers can be taught as they trained the AI robot to categorize fish and trash and to clean the ocean (Yang et al., 2023).

The next study examines the use of interactive robotic toys equipped with artificial intelligence in early childhood environments to facilitate the development of inquiry-based teaching (Kewalramani et al., 2021). A Design-Based Research (DBR) approach was employed, which is well-suited for small-scale educational research projects that involve collaboration among teachers, children, and researchers (Jetnikoff, 2015; Morgan, 2013). The investigation process was driven by a group of children who wanted to experience an adventure with their robot. Coji, an AI robot that displayed emojis (emotions), laughed, and danced, was programmed by the children with stories and tasks for Coji to perform. Their creative inquiry was evident when they attributed symbolic meaning to the robot, for example, when they described it in human-like terms and wondered if robots could die because their batteries cannot function underwater. The findings of this research contrast with studies that continue to raise questions and argue that the use of digital technologies, such as AI toys, may have a negative impact on education (Chaudron et al., 2017; Straker et al., 2018).

The study by Tanaka et al. (2007) was among the first to demonstrate that, under certain conditions, primary forms of prosocial behaviors can emerge through children's interaction with robots, in much the same way as with their peers. For this purpose, the researchers brought the humanoid robot Qrio into a classroom of children aged 18 to 24 months for more than five months. The results showed that, instead of losing interest over time, the children developed a bond with the robot and a level of socialization similar to that with a human friend. Additionally, Vircikova et al. (2015) evaluated the capabilities of the Nao robot in a school environment that used an emotional state recognition system to identify emotions. The emotional loop facilitated the design of its responses and the acquisition of emotional expressions through practice. During the experiment, the robot adjusted its emotions by analyzing the children's emotional reactions. The research showed that changing responses in different environments and personalizing interactions were both essential for developing a long-term relationship.

3 Conclusions

The concept of computer-assisted learning has facilitated the integration of technology into the classroom. As a result, education, learning environments, teaching methods, and educational infrastructure have been profoundly changed by the presence of computers and technology (Virani & Rautela, 2025). Moreover, immersive technologies such as augmented reality (AR), virtual reality (VR), and mixed reality (MR) have become powerful tools for providing students with immersive, interactive, and engaging experiences (Baxter & Hainey, 2024; Bailenson, 2018). The existence of these technologies leads us to the Edu-Metaverse, a superior form of educational environment where virtual and real, humans and machines, interact fully (Kin-Hon et al., 2023). The report "A whole new world" (Hirsh-Pasek et al., 2022) states that "The Metaverse of the future is likely to fully support augmented and virtual reality, artificial intelligence, and the integration of all these." In this way, students will have the ability to communicate and interact with other students and professors through individual or collective channels (Bazargani et al., 2025).

Today, digital technologies have completely transformed the human world. Advances in technology, such as 5G, artificial intelligence, and digital twins, have sparked the evolution and revolution of the next generation of the Internet, namely the Metaverse (Virani & Rautela, 2025). Previous researchers have expressed their views on how education can be positively transformed by incorporating new technologies (López-Belmonte et al., 2023; Arcila, 2020). However, some believe that the Metaverse is one of those technologies destined to fail, while others see it as an integral part of future life. Technology giants such as Meta, Microsoft, and Apple have invested billions of dollars in developing the Metaverse and its related technologies (Hussain et al., 2023), which are supported by components such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI), robotics, blockchain technology, the Internet of Things (IoT), and human-computer interaction (HCI) (Dwivedi et al., 2022).

With many of the world's commercial brands disappearing from urban centers as shoppers prefer online purchases, and with the immersive experiences provided by the Metaverse, we may see university campuses vanish (or at least shrink) in the next decade. Just as Amazon has revolutionized the retail industry, will Google, Meta, or other tech giants have a similar impact on the education sector (Hussain et al., 2023)? As a result, the impact of the Metaverse on education is still being examined and remains a significant topic for researchers to understand the opportunities and challenges it brings (Bizel et al., 2023).

Conflicts of Interest

The author declares no conflict of interest.

References

Adiguzel, T., Kaya, M. H., & Cansu, F. K. (2023). Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. Contemporary Educational Technology, 15(3), ep429. https://doi.org/10.30935/cedtech/13152

Ahmad, S. F., Alam, M. M., Rahmat, Mohd. K., Mubarik, M. S., & Hyder, S. I. (2022). Academic and Administrative Role of Artificial Intelligence in Education. Sustainability, 14(3), 1101. https://doi.org/10.3390/su14031101

Ahuja, A. S., Polascik, B. W., Doddapaneni, D., Byrnes, E. S., & Sridhar, J. (2023). The digital metaverse: Applications in artificial intelligence, medical education, and integrative health. Integrative Medicine Research, 12(1), 100917. https://doi.org/10.1016/j.imr.2022.100917

Aksakal, N. (2015). Theoretical view to the approach of the edutainment. Procedia-Social and Behavioral Sciences, 186, 1232-1239.
https://doi.org/10.1016/j.sbspro.2015.04.081

Alexiou, T., Penteri, E., Serafim, M., Gioftsali, K., Ntousi, I., & Tsiadimos, N. (2022). Kiki goes camping! Educational scenarios EAN. Aristotle University of Thessaloniki.
https://doi.org/10.26262/heal.auth.ir.341660

Allaoua Chelloug, S., Ashfaq, H., A. Alsuhibany, S., Shorfuzzaman, M., Alsufyani, A., Jalal, A., & Park, J. (2023). Real Objects Understanding Using 3D Haptic Virtual Reality for E-Learning Education. Computers, Materials & Continua, 74(1), 1607–1624.
https://doi.org/10.32604/cmc.2023.032245

Alzahrani, A. (2022). A systematic review of artificial intelligence in education in the arab world. Revista Amazonia Investiga, 11(54), 293–305. CLOCKSS.
https://doi.org/10.34069/ai/2022.54.06.28

Annuš, N. (2024). Education in the Age of Artificial Intelligence. TEM Journal, 404–413. Portico.
https://doi.org/10.18421/tem131-42

Anyoha, R. (2017). The history of artificial intelligence. Science in the News. Harvard University.
https://sites.harvard.edu

Arslan, K. (2020). Artificial intelligence and applications in education. Western Anatolia Journal of Educational Sciences, 11(1), 71-80.
https://dergipark.org.tr

Atta, G., Abdelsattar, A., Elfiky, D., Zahran, M., Farag, M., & Slim, S. O. (2022). Virtual Reality in Space Technology Education. Education Sciences, 12(12), 890.
https://doi.org/10.3390/educsci12120890

Bailenson, J. (2018). Experience on demand: What virtual reality is, how it works, and what it can do. W. W. Norton & Company.

Baniassad, E., Zamprogno, L., Hall, B., & Holmes, R. (2021). STOP THE (AUTOGRADER) INSANITY: Regression Penalties to Deter Autograder Overreliance. Proceedings of the 52nd ACM Technical Symposium on Computer Science Education, 1062–1068.
https://doi.org/10.1145/3408877.3432430

Baxter, G., & Hainey, T. (2023). Using immersive technologies to enhance the student learning experience. Interactive Technology and Smart Education, 21(3), 403–425.
https://doi.org/10.1108/itse-05-2023-0078

Binns, R. (2018, February). Fairness in machine learning: Lessons from political philosophy. In Conference on Fairness, Accountability, and Transparency. New York, NY, USA.

BIZEL, G. (2023). A Bibliometric Analysis: Metaverse in Education Concept. Journal of Metaverse, 3(2), 133–143.
https://doi.org/10.57019/jmv.1310768

Bohil, C. J., Alicea, B., & Biocca, F. A. (2011). Virtual reality in neuroscience research and therapy. Nature Reviews Neuroscience, 12(12), 752–762.
https://doi.org/10.1038/nrn3122

Brandtzaeg, P. B., & Følstad, A. (2018). Chatbots. Interactions, 25(5), 38–43.
https://doi.org/10.1145/3236669

Benjamin, E. (2023). Why AI detectors think the US Constitution was written by AI. Ars Technica.
https://arstechnica.com

Borysenko, D. (2023, May). Artificial intelligence in vocational education: Pandora's box or new opportunities. In Forum-Sois 2023: Collection of Materials of the 4th and 5th International Scientific and Practical WebForum. Kyiv, Kharkiv.

Caucheteux, C., Hodgkins, L.-B., Batifol, V., Fouché, L., & Romero, M. (2024). Students' Perspective on the Use of Artificial Intelligence in Education. Creative Applications of Artificial Intelligence in Education, 101–113.
https://doi.org/10.1007/978-3-031-55272-4_8

Causo, A., Vo, G. T., Chen, I.-M., & Yeo, S. H. (2015). Design of Robots Used as Education Companion and Tutor. Robotics and Mechatronics, 75–84.
https://doi.org/10.1007/978-3-319-22368-1_8

Chalkiadakis, A., Seremetaki, A., Kanellou, A., Kallishi, M., Morfopoulou, A., Moraitaki, M., & Mastrokoukou, S. (2024). Impact of Artificial Intelligence and Virtual Reality on Educational Inclusion: A Systematic Review of Technologies Supporting Students with Disabilities. Education Sciences, 14(11), 1223.
https://doi.org/10.3390/educsci14111223

Chatterjee, S., & Bhattacharjee, K. K. (2020). Adoption of artificial intelligence in higher education: a quantitative analysis using structural equation modelling. Education and Information Technologies, 25(5), 3443–3463.
https://doi.org/10.1007/s10639-020-10159-7

Chen, J. J., & Lin, J. C. (2023). Artificial intelligence as a double-edged sword: Wielding the POWER principles to maximize its positive effects and minimize its negative effects. Contemporary Issues in Early Childhood, 25(1), 146–153.
https://doi.org/10.1177/14639491231169813

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. IEEE Access, 8, 75264–75278.
https://doi.org/10.1109/access.2020.2988510

Chen, Y.-L., Hsu, C.-C., Lin, C.-Y., & Hsu, H.-H. (2022). Robot-Assisted Language Learning: Integrating Artificial Intelligence and Virtual Reality into English Tour Guide Practice. Education Sciences, 12(7), 437.
https://doi.org/10.3390/educsci12070437

China, D. (2022). Metaverse Report: Future Is Here; Global XR Industry Insight. Author, Beijing, China.

Chiu, T. K. F., Ahmad, Z., Ismailov, M., & Sanusi, I. T. (2024). What are artificial intelligence literacy and competency? A comprehensive framework to support them. Computers and Education Open, 6, 100171.
https://doi.org/10.1016/j.caeo.2024.100171

Chytas, D., Johnson, E. O., Piagkou, M., Mazarakis, A., Babis, G. C., Chronopoulos, E., Nikolaou, V. S., Lazaridis, N., & Natsis, K. (2020). The role of augmented reality in Anatomical education: An overview. Annals of Anatomy - Anatomischer Anzeiger, 229, 151463.
https://doi.org/10.1016/j.aanat.2020.151463

Ciesla, R. (2024). The Book of Chatbots. Springer Nature Switzerland.
https://doi.org/10.1007/978-3-031-51004-5

Crawford, K. (2021). Atlas of AI.
https://doi.org/10.12987/9780300252392

Chaudron, S., Di Gioia, R., Gemo, M., Holloway, D., Marsh, J., Mascheroni, G., Peter, J., & Yamada-Rice, D. (2017). Kaleidoscope on the Internet of Toys: Safety, security, privacy and societal insights. Publications Office of the European Union.

Deriba, F. G., & Sanusi, I. T. (2025). Artificial intelligence in Ethiopian school curriculum: Educators' practices, challenges, and recommendations. Computers and Education Open, 8, 100251.
https://doi.org/10.1016/j.caeo.2025.100251

DiPaola, D., Ali, S., & Breazeal, C. (2021). What are GANs?: Introducing generative adversarial networks to middle school students. In Proceedings of the 11th Symposium on Education Advances in Artificial Intelligence (EAAI-21). London, UK.

Druga, S., Vu, S. T., Likhith, E., & Qiu, T. (2019). Inclusive AI literacy for kids around the world. Proceedings of FabLearn 2019, 104–111.
https://doi.org/10.1145/3311890.3311904

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., … Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. International Journal of Information Management, 66, 102542.
https://doi.org/10.1016/j.ijinfomgt.2022.102542

Editors' Association. (2025). Code of ethics for the use of productive artificial intelligence by journalists.
https://www.esiea.gr

Edwards, B. I., Bielawski, K. S., Prada, R., & Cheok, A. D. (2018). Haptic virtual reality and immersive learning for enhanced organic chemistry instruction. Virtual Reality, 23(4), 363–373.
https://doi.org/10.1007/s10055-018-0345-4

Elmasry, T., Khan, H., Yee, L., Hazan, E., & Kelly, G. (2022). Value creation in the metaverse. McKinsey & Company.
https://www.mckinsey.com

Elmi-Terander, A., Burström, G., Nachabe, R., Skulason, H., Pedersen, K., Fagerlund, M., Ståhl, F., Charalampidis, A., Söderman, M., Holmin, S., Babic, D., Jenniskens, I., Edström, E., & Gerdhem, P. (2019). Pedicle Screw Placement Using Augmented Reality Surgical Navigation With Intraoperative 3D Imaging. Spine, 44(7), 517–525.
https://doi.org/10.1097/brs.0000000000002876

Eriksson, E., & Torgersson, O. (2021). "The concept of learning goals will always be in my head" - Aligning and Applying Learning Goals in Participatory Design in a School Context. Interaction Design and Children, 153–159.
https://doi.org/10.1145/3459990.3460705

European Parliament. (2021). Report on artificial intelligence in education, culture and the audiovisual sector.
https://www.europarl.europa.eu

Fauzi, A. L., Kusumah, Y. S., Nurlaelah, E., & Juandi, D. (2023). Computational thinking education in K-12 artificial intelligence literacy and physical computing. Education 3-13, 53(4), 687–689.
https://doi.org/10.1080/03004279.2023.2271019

Ferikoğlu, D., & Akgün, E. (2022). An Investigation of Teachers' Artificial Intelligence Awareness: A Scale Development Study. Malaysian Online Journal of Educational Technology, 10(3), 215–231.
https://doi.org/10.52380/mojet.2022.10.3.407

Floridi, L., & Cowls, J. (2019). A Unified Framework of Five Principles for AI in Society. Harvard Data Science Review.
https://doi.org/10.1162/99608f92.8cd550d1

Fowler, G. A. (2023). What to do when you're accused of AI cheating.The Washington Post.
https://www.washingtonpost.com

Ge, Z., & Hu, Y. (2020). Innovative Application of Artificial Intelligence (AI) in the Management of Higher Education and Teaching. Journal of Physics: Conference Series, 1533(3), 032089.
https://doi.org/10.1088/1742-6596/1533/3/032089

Goel, A. (2016). Meet Jill Watson: Georgia Tech's first AI teaching assistant. Georgia Tech Professional Education.
https://pe.gatech.edu

Goertzel, B. (2014). Artificial General Intelligence: Concept, State of the Art, and Future Prospects. Journal of Artificial General Intelligence, 5(1), 1–48.
https://doi.org/10.2478/jagi-2014-0001

Gómez-León, M. I. (2022). Development of empathy through Socioemotional Artificial Intelligence. Papeles Del Psicólogo - Psychologist Papers, 43(3), 218.
https://doi.org/10.23923/pap.psicol.2996

Grajewski, D., Górski, F., Hamrol, A., & Zawadzki, P. (2015). Immersive and Haptic Educational Simulations of Assembly Workplace Conditions. Procedia Computer Science, 75, 359–368.
https://doi.org/10.1016/j.procs.2015.12.258

Gstrein, O. J. (2022). European AI Regulation: Brussels Effect versus Human Dignity? Zeitschrift Für Europarechtliche Studien, 25(4), 755–772.
https://doi.org/10.5771/1435-439x-2022-4-755

Gstrein, O. J., Haleem, N., & Zwitter, A. (2024). General-purpose AI regulation and the European Union AI Act. Internet Policy Review, 13(3).
https://doi.org/10.14763/2024.3.1790

Güneyli, A., Burgul, N. S., Dericioğlu, S., Cenkova, N., Becan, S., Şimşek, Ş. E., & Güneralp, H. (2024). Exploring Teacher Awareness of Artificial Intelligence in Education: A Case Study from Northern Cyprus. European Journal of Investigation in Health, Psychology and Education, 14(8), 2358–2376.
https://doi.org/10.3390/ejihpe14080156

Handby, E. (2021). Classroom Games to Teach Contemporary Political Theory. Journal of Political Science Education, 17(sup1), 23–31.
https://doi.org/10.1080/15512169.2021.1914640

Harris, D. E. (2023). Voluntary curbs aren't enough: AI risk requires a binding international treaty. Centre for International Governance Innovation.
https://www.cigionline.org

Helberger, N., & Diakopoulos, N. (2023). ChatGPT and the AI Act. Internet Policy Review, 12(1).
https://doi.org/10.14763/2023.1.1682

Ho, C. (2022). Research on Teaching of Metaverse Technology Flipped the MICE Education. 2022 3rd International Conference on Education, Knowledge and Information Management (ICEKIM), 592–596.
https://doi.org/10.1109/icekim55072.2022.00136

Ho, K.-H., Hou, Y., Chu, C. F. C., Chan, C.-K., Pan, H., & Chan, T.-T. (2023). Work in Progress: An AI-Assisted Metaverse for Computer Science Education. 2023 IEEE World Engineering Education Conference (EDUNINE), 1–4.
https://doi.org/10.1109/edunine57531.2023.10102819

Holmes, W. (2019). Artificial Intelligence in Education. Encyclopedia of Education and Information Technologies, 1–16.
https://doi.org/10.1007/978-3-319-60013-0_107-1

Hussain, S. (2023). Metaverse for education – Virtual or real? Frontiers in Education, 8.
https://doi.org/10.3389/feduc.2023.1177429

Hirsh-Pasek, K., Zosh, J. M., Hadani, H. S., Golinkoff, R. M., Clark, K., Donohue, C., & Wartella, E. (2022). A whole new world: Education meets the metaverse. Brookings Institution.
https://www.brookings.edu

Impact Research. (2023). Teachers and students embrace ChatGPT for education. Walton Family Foundation.
https://www.waltonfamilyfoundation.org

Ishihara, H., Wu, B., & Asada, M. (2018). Identification and Evaluation of the Face System of a Child Android Robot Affetto for Surface Motion Design. Frontiers in Robotics and AI, 5.
https://doi.org/10.3389/frobt.2018.00119

Internet Matters Team. (2017). The secret life of six year olds. Internet Matters.
https://www.internetmatters.org

James, F., & Figaro-Henry, S. (2017). Building collective leadership capacity using collaborative twenty-first century digital tools. School Leadership & Management, 37(5), 520–536.
https://doi.org/10.1080/13632434.2017.1367277

Jetnikoff, A. (2015). Design based research methodology for teaching with technology in English. English in Australia, 50(3), 56–60.

Kaliisa, R., Kluge, A., & Mørch, A. I. (2021). Overcoming Challenges to the Adoption of Learning Analytics at the Practitioner Level: A Critical Analysis of 18 Learning Analytics Frameworks. Scandinavian Journal of Educational Research, 66(3), 367–381.
https://doi.org/10.1080/00313831.2020.1869082

Kang, H. (2023). Artificial intelligence and its influence in adult learning in China. Higher Education, Skills and Work-Based Learning, 13(3), 450–464.
https://doi.org/10.1108/heswbl-01-2023-0017

Karan, B., & Angadi, G. R. (2023). Artificial Intelligence Integration into School Education: A Review of Indian and Foreign Perspectives. Millennial Asia, 16(1), 173–199.
https://doi.org/10.1177/09763996231158229

Kassa, E. A., & Mekonnen, E. A. (2022). Computational thinking in the Ethiopian secondary school ICT curriculum. Computer Science Education, 32(4), 502–531.
https://doi.org/10.1080/08993408.2022.2095594

Kewalramani, S., Kidman, G., & Palaiologou, I. (2021). Using Artificial Intelligence (AI)-interfaced robotic toys in early childhood settings: a case for children's inquiry literacy. European Early Childhood Education Research Journal, 29(5), 652–668.
https://doi.org/10.1080/1350293x.2021.1968458

Kewalramani, S., Palaiologou, I., Dardanou, M., Allen, K.-A., & Phillipson, S. (2021). Using robotic toys in early childhood education to support children's social and emotional competencies. Australasian Journal of Early Childhood, 46(4), 355–369.
https://doi.org/10.1177/18369391211056668

Kirchner, J. H., Ahmad, L., Aaronson, S., & Leike, J. (2023). New AI classifier for indicating AI-written text. OpenAI.
https://openai.com

Kokane, A., Singhal, H., Mukherjee, S., & Reddy, G. R. M. (2014). Effective E-learning using 3D Virtual Tutors and WebRTC Based Multimedia Chat. 2014 International Conference on Recent Trends in Information Technology, 1–6.
https://doi.org/10.1109/icrtit.2014.6996209

Kokash, H. A., Shah Alam, S., Ahmed, S., Khattak, A. N., & Tariq, B. (2024). Using Virtual Reality in Tourism Destination Decision: A Young Saudi Tourists' Perspective with Habit is a Mediator. Journal of Quality Assurance in Hospitality & Tourism, 1–34.
https://doi.org/10.1080/1528008x.2023.2299762

Kölemen, E. B., & Yıldırım, B. (2025). A new era in early childhood education (ECE): Teachers' opinions on the application of artificial intelligence. Education and Information Technologies, 30(12), 17405–17446.
https://doi.org/10.1007/s10639-025-13478-9

Kong, S.-C., Cheung, W. M.-Y., & Zhang, G. (2022). Evaluating artificial intelligence literacy courses for fostering conceptual learning, literacy and empowerment in university students: Refocusing to conceptual building. Computers in Human Behavior Reports, 7, 100223.
https://doi.org/10.1016/j.chbr.2022.100223

Kong, S.-C., Korte, S.-M., Burton, S., Keskitalo, P., Turunen, T., Smith, D., Wang, L., Lee, J. C.-K., & Beaton, M. C. (2024). Artificial Intelligence (AI) literacy – an argument for AI literacy in education. Innovations in Education and Teaching International, 62(2), 477–483.
https://doi.org/10.1080/14703297.2024.2332744

Kong, S.-C., Man-Yin Cheung, W., & Zhang, G. (2021). Evaluation of an artificial intelligence literacy course for university students with diverse study backgrounds. Computers and Education: Artificial Intelligence, 2, 100026.
https://doi.org/10.1016/j.caeai.2021.100026

Kordon, A. K. (2020). Applying Data Science. Springer International Publishing.
https://doi.org/10.1007/978-3-030-36375-8

Kotsilieris, T., & Dimopoulou, N. (2013). The evolution of e-learning in the context of 3D virtual worlds. Electronic Journal of e-Learning, 11(2), 147–167.
https://files.eric.ed.gov

Kozima, H., Michalowski, M. P., & Nakagawa, C. (2008). Keepon. International Journal of Social Robotics, 1(1), 3–18.
https://doi.org/10.1007/s12369-008-0009-8

Kulieshov, S. O. (2022). Features of the use of artificial intelligence in the US higher education system. In Modern computer and information systems and technologies: Materials of the 3rd All-Ukrainian scientific-practical internet conference (pp. 448–450). TDATU.
http://elar.tsatu.edu.ua

Kurian, N. (2023). AI's empathy gap: The risks of conversational Artificial Intelligence for young children's well-being and key ethical considerations for early childhood education and care. Contemporary Issues in Early Childhood, 26(1), 132–139.
https://doi.org/10.1177/14639491231206004

Kaliuzhna, O. (2023, May). Neural networks: Use of innovative programs that generate various content with the help of artificial intelligence in foreign literature lessons. In Forum-Sois 2023: Collection of Materials of the 4th and 5th International Scientific and Practical WebForum. Kyiv, Kharkiv.

Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI chatbots in education: systematic literature review. International Journal of Educational Technology in Higher Education, 20(1).
https://doi.org/10.1186/s41239-023-00426-1

Lao, N. (2020). Reorienting machine learning education towards tinkerers and ML-engaged citizens (Unpublished doctoral dissertation). Massachusetts Institute of Technology, USA.

Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education: A scoping literature review. Computers and Education: Artificial Intelligence, 3, 100101.
https://doi.org/10.1016/j.caeai.2022.100101

Lee, I., Zhang, H., Moore, K., Zhou, X., Perret, B., Cheng, Y., Zheng, R., & Pu, G. (2022). AI Book Club. Proceedings of the 53rd ACM Technical Symposium on Computer Science Education, 202–208.
https://doi.org/10.1145/3478431.3499318

Li, P. H., & Chen, J. J. (2022). The Glocalization of Early Childhood Curriculum. https://doi.org/10.4324/9781003274865

Li, X. (2007). Intelligent Agent–Supported Online Education. Decision Sciences Journal of Innovative Education, 5(2), 311–331. Portico. https://doi.org/10.1111/j.1540-4609.2007.00143.x

Lin, P., Van Brummelen, J., Lukin, G., Williams, R., & Breazeal, C. (2020). Zhorai: Designing a Conversational Agent for Children to Explore Machine Learning Concepts. Proceedings of the AAAI Conference on Artificial Intelligence, 34(09), 13381–13388. https://doi.org/10.1609/aaai.v34i09.7061

Long, D., & Magerko, B. (2020). What is AI Literacy? Competencies and Design Considerations. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3313831.3376727

López-Belmonte, J., Moreno-Guerrero, A.-J., López-Núñez, J.-A., & Hinojo-Lucena, F.-J. (2020). Augmented reality in education. A scientific mapping in Web of Science. Interactive Learning Environments, 31(4), 1860–1874. https://doi.org/10.1080/10494820.2020.1859546

López-Belmonte, J., Pozo-Sánchez, S., Moreno-Guerrero, A.-J., & Marín-Marín, J.-A. (2023). We've reached the GOAL. Teaching Methodology for Transforming Learning in the METAVERSE. A teaching innovation project. Metaverse Basic and Applied Research, 2, 30. https://doi.org/10.56294/mr202330

McFadden, A., & Thomas, K. (2016). Parent Perspectives on the Implementation of a Digital Documentation Portal in an Early Learning Centre. Australasian Journal of Early Childhood, 41(4), 86–94. https://doi.org/10.1177/183693911604100411

McKnight, L. (2021). Electric Sheep? Humans, Robots, Artificial Intelligence, and the Future of Writing. Changing English, 28(4), 442–455. https://doi.org/10.1080/1358684x.2021.1941768

McKnight, R. R., Pean, C. A., Buck, J. S., Hwang, J. S., Hsu, J. R., & Pierrie, S. N. (2020). Virtual Reality and Augmented Reality—Translating Surgical Training into Surgical Technique. Current Reviews in Musculoskeletal Medicine, 13(6), 663–674. https://doi.org/10.1007/s12178-020-09667-3

McNicholas, T. (2023). New Jersey high school students accused of making AI-generated pornographic images of classmates. CBS News. https://www.cbsnews.com

Madiega, T. (2024). Artificial intelligence act. European Parliament. https://www.europarl.europa.eu

Mengesha, Z., Heldreth, C., Lahav, M., Sublewski, J., & Tuennerman, E. (2021). "I don't Think These Devices are Very Culturally Sensitive."—Impact of Automated Speech Recognition Errors on African Americans. Frontiers in Artificial Intelligence, 4. https://doi.org/10.3389/frai.2021.725911

Mertala, P., Fagerlund, J., & Calderon, O. (2022). Finnish 5th and 6th grade students' pre-instructional conceptions of Artificial Intelligence (AI) and their implications for AI literacy education. https://doi.org/10.35542/osf.io/38e4x

Milmo, D., & Stacey, K. (2023, November 2). Five takeaways from UK's AI safety summit at Bletchley Park. The Guardian. https://www.theguardian.com

Mintz, R., Litvak, S., & Yair, Y. (2001). 3D-virtual reality in science education: An implication for astronomy teaching. Journal of Computers in Mathematics and Science Teaching, 20(3), 293–305.

Morgan, A.-M. (2013). 'Proof of concept': Beginning to use Design-Based Research to improve science literacies for middle years learners. The Australian Journal of Language and Literacy, 36(1), 3–16. https://doi.org/10.1007/bf03652085

Morimoto, T., Kobayashi, T., Hirata, H., Otani, K., Sugimoto, M., Tsukamoto, M., Yoshihara, T., Ueno, M., & Mawatari, M. (2022). XR (Extended Reality: Virtual Reality, Augmented Reality, Mixed Reality) Technology in Spine Medicine: Status Quo and Quo Vadis. Journal of Clinical Medicine, 11(2), 470. https://doi.org/10.3390/jcm11020470

Müller, V. C. (2020). Ethics of artificial intelligence and robotics. In E. N. Zalta (Ed.), The Stanford encyclopedia of philosophy (Fall 2020 ed.). Stanford University. https://plato.stanford.edu

Miao, F., & Holmes, W. (2021). Artificial intelligence and education. Guidance for policy-makers. https://doi.org/10.54675/pcsp7350

Neff, G., & Nagy, P. (2016). Talking to bots: Symbiotic agency and the case of Tay. International Journal of Communication, 10, 4915–4931. https://ijoc.org

Ng, D. T. K., Leung, J. K. L., Su, M. J., Yim, I. H. Y., Qiao, M. S., & Chu, S. K. W. (2022). AI Literacy in K-16 Classrooms. Springer International Publishing. https://doi.org/10.1007/978-3-031-18880-0

Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B.-P. T. (2022). Ethical principles for artificial intelligence in education. Education and Information Technologies, 28(4), 4221–4241. https://doi.org/10.1007/s10639-022-11316-w

Oppenlaender, J., Kuosmanen, E., Lucero, A., & Hosio, S. (2021). Hardhats and Bungaloos: Comparing Crowdsourced Design Feedback with Peer Design Feedback in the Classroom. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 1–14. https://doi.org/10.1145/3411764.3445380

Paek, S., & Kim, N. (2021). Analysis of Worldwide Research Trends on the Impact of Artificial Intelligence in Education. Sustainability, 13(14), 7941. https://doi.org/10.3390/su13147941

Pandey, A. K., Ali, M., & Alami, R. (2013). Towards a Task-Aware Proactive Sociable Robot Based on Multi-state Perspective-Taking. International Journal of Social Robotics, 5(2), 215–236. https://doi.org/10.1007/s12369-013-0181-3

Papadakis, S. (2020). Apps to Promote Computational Thinking Concepts and Coding Skills in Children of Preschool and Pre-Primary School Age. Mobile Learning Applications in Early Childhood Education, 101–121. https://doi.org/10.4018/978-1-7998-1486-3.ch006

Papadakis, S. (2022). Apps to Promote Computational Thinking and Coding Skills to Young Age Children: A Pedagogical Challenge for the 21st Century Learners. Educational Process International Journal, 11(1). https://doi.org/10.22521/edupij.2022.111.1

Papadakis, S., Kiv, A. E., Kravtsov, H. M., Osadchyi, V. V., Marienko, M. V., Pinchuk, O. P., Shyshkina, M. P., Sokolyuk, O. M., Mintii, I. S., Vakaliuk, T. A., Azarova, L. E., Kolgatina, L. S., Amelina, S. M., Volkova, N. P., Velychko, V. Ye., Striuk, A. M., & Semerikov, S. O. (2023). ACNS Conference on Cloud and Immersive Technologies in Education: Report. CTE Workshop Proceedings, 10, 1–44. https://doi.org/10.55056/cte.544

Papadakis, S., Kiv, A. E., Kravtsov, H. M., Osadchyi, V. V., Marienko, M. V., Pinchuk, O. P., ... & Striuk, A. M. (2023b). Unlocking the power of synergy: the joint force of cloud technologies and augmented reality in education. In Joint Proceedings of the 10th Workshop on Cloud Technologies in Education (CTE 2021) and 5th International Workshop on Augmented Reality in Education (AREdu 2022), Kryvyi Rih, Ukraine, May 23, 2022. CEUR Workshop Proceedings.

Papadakis, S., Zourmpakis, A.-I., Kasotaki, S., & Kalogiannakis, M. (2024). Teachers' perspectives on integrating adaptive gamification applications into science teaching. Journal of Electrical Systems, 20(11s), 2593–2600.

Parnell, W. A., & Bartlett, J. (2012). iDocument: How smartphones and tablets are changing documentation in preschool and primary classrooms. Young Children, 67(3), 50–57.

Peña Arcila, J. B. (2020). Master of Ibero American virtual environment education. Metaverse, 1(1), 11. https://doi.org/10.54517/met.v1i1.1779

Pratama, M. P., Sampelolo, R., & Lura, H. (2023). Revolutionizing education: harnessing the power of artificial intelligence for personalized learning. Klasikal: Journal of education, language teaching and science, 5(2), 350-357. https://doi.org/10.52208/klasikal.v5i2.877

Prentzas, J. (2013). Artificial Intelligence Methods in Early Childhood Education. Artificial Intelligence, Evolutionary Computing and Metaheuristics, 169–199. https://doi.org/10.1007/978-3-642-29694-9_8

Raza, A., Rehman, A., Sehar, R., Alamri, F. S., Alotaibi, S., Al Ghofaily, B., & Saba, T. (2024). Optimized virtual reality design through user immersion level detection with novel feature fusion and explainable artificial intelligence. PeerJ Computer Science, 10, e2150. Portico. https://doi.org/10.7717/peerj-cs.2150

Ryzheva, N., Nefodov, D., Romanyuk, S., Marynchenko, H., & Kudla, M. (2024). Artificial Intelligence in higher education: opportunities and challenges. Revista Amazonia Investiga, 13(73), 284–296. CLOCKSS. https://doi.org/10.34069/ai/2024.73.01.24

Safari Bazargani, J., Sadeghi-Niaraki, A., & Choi, S.-M. (2025). A Survey and Framework for Education in the Metaverse. IEEE Access, 13, 33231–33245. https://doi.org/10.1109/access.2025.3543496

Şahín Kölemen, C. (2024). Artificial intelligence technologies and ethics in educational processes: solution suggestions and results. Innoeduca. International Journal of Technology and Educational Innovation, 10(2), 201–216. https://doi.org/10.24310/ijtei.102.2024.19806

Salamanca, L. P., Carini, A. R., Lee, M. A., Dykstra, K., Whitehill, J., Angus, D., Wiles, J., Reilly, J. S., & Bartlett, M. S. (2012). Characterizing the temporal dynamics of student-teacher discourse. 2012 IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL), 1–2. https://doi.org/10.1109/devlrn.2012.6400840

Samuel, G., Chubb, J., & Derrick, G. (2021). Boundaries Between Research Ethics and Ethical Research Use in Artificial Intelligence Health Research. Journal of Empirical Research on Human Research Ethics, 16(3), 325–337. https://doi.org/10.1177/15562646211002744

Santos, R., Margarido, C., Pocinho, R., Silva, T., & Póvoa, V. (2020). Evaluation of an educational project for the development of the autonomy of life in young people leaving residential care. Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality, 821–826. https://doi.org/10.1145/3434780.3436591

Schlemmer, E., & Backes, L. (2015). Learning in Metaverses. Advances in Educational Technologies and Instructional Design.
https://doi.org/10.4018/978-1-4666-6351-0

Schönborn, K. J., Bivall, P., & Tibell, L. A. E. (2011). Exploring relationships between students' interaction and learning with a haptic virtual biomolecular model. Computers & Education, 57(3), 2095–2105.
https://doi.org/10.1016/j.compedu.2011.05.013

Serholt, S., Pareto, L., Ekström, S., & Ljungblad, S. (2020). Trouble and Repair in Child–Robot Interaction: A Study of Complex Interactions With a Robot Tutee in a Primary School Classroom. Frontiers in Robotics and AI, 7.
https://doi.org/10.3389/frobt.2020.00046

Shamir, G., & Levin, I. (2022). Teaching machine learning in elementary school. International Journal of Child-Computer Interaction, 31, 100415.
https://doi.org/10.1016/j.ijcci.2021.100415

Singh, D. D., Das, S., & Chakraborty, A. (2023). FairAssign: Stochastically Fair Driver Assignment in Gig Delivery Platforms. 2023 ACM Conference on Fairness Accountability and Transparency, 753–763.
https://doi.org/10.1145/3593013.3594040

Stephenson, N. (2022). Snow crash. Viking.

Storey, V. A., & Beeman, T. E. (2023, October). The impact of human and machine adjuncts on reshaping higher education institutions in the education 4.0 era. In Proceedings of the Northeast Business and Economics Association (NBEA) Annual Conference. Philadelphia, PA, USA.

Storey, V. A., & Wagner, A. (2024). Integrating Artificial Intelligence (AI) Into Adult Education. International Journal of Adult Education and Technology, 15(1), 1–15.
https://doi.org/10.4018/ijaet.345921

Straker, L., Zabatiero, J., Danby, S., Thorpe, K., & Edwards, S. (2018). Conflicting Guidelines on Young Children's Screen Time and Use of Digital Technology Create Policy and Practice Dilemmas. The Journal of Pediatrics, 202, 300–303.
https://doi.org/10.1016/j.jpeds.2018.07.019

Stratan-Artyshkova, T., Kozak, K., Syrotina, O., Lisnevska, N., Sichkar, S., Pertsov, O., & Kuchai, O. (2022). Formation of new approaches to the use of information technology and search for innovative methods of training specialists within the Pan-European educational space. International Journal of Computer Science and Network Security, 22(8), 97–104.
https://doi.org/10.22937/IJCSNS.2022.22.8.13

Su, J., & Yang, W. (2022). Artificial intelligence in early childhood education: A scoping review. Computers and Education: Artificial Intelligence, 3, 100049.
https://doi.org/10.1016/j.caeai.2022.100049

Su, J., & Yang, W. (2023). Artificial Intelligence (AI) literacy in early childhood education: an intervention study in Hong Kong. Interactive Learning Environments, 32(9), 5494–5508.
https://doi.org/10.1080/10494820.2023.2217864

Su, J., & Yang, W. (2023). AI literacy curriculum and its relation to children's perceptions of robots and attitudes towards engineering and science: An intervention study in early childhood education. Journal of Computer Assisted Learning, 40(1), 241–253. Portico.
https://doi.org/10.1111/jcal.12867

Su, J., & Zhong, Y. (2022). Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. Computers and Education: Artificial Intelligence, 3, 100072.
https://doi.org/10.1016/j.caeai.2022.100072

Su, J., Guo, K., Chen, X., & Chu, S. K. W. (2023). Teaching artificial intelligence in K–12 classrooms: a scoping review. Interactive Learning Environments, 32(9), 5207–5226.
https://doi.org/10.1080/10494820.2023.2212706

Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial Intelligence (AI) Literacy in Early Childhood Education: The Challenges and Opportunities. Computers and Education: Artificial Intelligence, 4, 100124.
https://doi.org/10.1016/j.caeai.2023.100124

Su, J., Zhong, Y., & Ng, D. T. K. (2022). A meta-review of literature on educational approaches for teaching AI at the K-12 levels in the Asia-Pacific region. Computers and Education: Artificial Intelligence, 3, 100065.
https://doi.org/10.1016/j.caeai.2022.100065

Talton, J. O., Dusad, K., Koiliaris, K., & Kumar, R. S. (2019). How do People Sort by Ratings? Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 1–10.
https://doi.org/10.1145/3290605.3300535

Tanaka, F., Cicourel, A., & Movellan, J. R. (2007). Socialization between toddlers and robots at an early childhood education center. Proceedings of the National Academy of Sciences, 104(46), 17954–17958.
https://doi.org/10.1073/pnas.0707769104

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(1).
https://doi.org/10.1186/s40561-023-00237-x

Touretzky, D., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What Should Every Child Know about AI? Proceedings of the AAAI Conference on Artificial Intelligence, 33(01), 9795–9799.
https://doi.org/10.1609/aaai.v33i01.33019795

Vartiainen, H., Tedre, M., & Valtonen, T. (2020). Learning machine learning with very young children: Who is teaching whom? International Journal of Child-Computer Interaction, 25, 100182.
https://doi.org/10.1016/j.ijcci.2020.100182

Veale, M., & Zuiderveen Borgesius, F. (2021). Demystifying the Draft EU Artificial Intelligence Act — Analysing the good, the bad, and the unclear elements of the proposed approach. Computer Law Review International, 22(4), 97–112.
https://doi.org/10.9785/cri-2021-220402

Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., Felländer, A., Langhans, S. D., Tegmark, M., & Fuso Nerini, F. (2020). The role of artificial intelligence in achieving the Sustainable Development Goals. Nature Communications, 11(1).
https://doi.org/10.1038/s41467-019-14108-y

Virani, S., & Rautela, S. (2024). Metaverse and education: identifying key themes and future research trajectories. The International Journal of Information and Learning Technology, 42(1), 84–106.
https://doi.org/10.1108/ijilt-05-2024-0083

Vircikova, M., Magyar, G., & Sincak, P. (2015). The Affective Loop: A Tool for Autonomous and Adaptive Emotional Human-Robot Interaction. Robot Intelligence Technology and Applications 3, 247–254.
https://doi.org/10.1007/978-3-319-16841-8_23

Virtue, P. (2021). GANs Unplugged. Proceedings of the AAAI Conference on Artificial Intelligence, 35(17), 15664–15668.
https://doi.org/10.1609/aaai.v35i17.17845

von Garrel, J., & Mayer, J. (2023). Artificial Intelligence in studies—use of ChatGPT and AI-based tools among students in Germany. Humanities and Social Sciences Communications, 10(1).
https://doi.org/10.1057/s41599-023-02304-7

Webb, M., Tracey, M., Harwin, W., Tokatli, O., Hwang, F., Johnson, R., Barrett, N., & Jones, C. (2021). Haptic-enabled collaborative learning in virtual reality for schools. Education and Information Technologies, 27(1), 937–960.
https://doi.org/10.1007/s10639-021-10639-4

Welsh, W. F., & Windmiller, G. (2020, January). Teaching moon phases and eclipses in virtual reality. In 235th Meeting of the American Astronomical Society. Honolulu, HI, USA.

Whittlestone, J., Nyrup, R., Alexandrova, A., & Cave, S. (2019). The Role and Limits of Principles in AI Ethics. Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society, 195–200.
https://doi.org/10.1145/3306618.3314289

White, G. (2018, December 3). Child advice chatbots fail to spot sexual abuse. BBC News.
https://www.bbc.co.uk

Williams, R. (2018). PopBots: Leveraging social robots to aid preschool children's artificial intelligence education (Unpublished master's thesis). Massachusetts Institute of Technology.

Williams, R., Ali, S., Devasia, N., DiPaola, D., Hong, J., Kaputsos, S. P., Jordan, B., & Breazeal, C. (2022). AI+Ethics Curricula for Middle School Youth: Lessons Learned from Three Project-Based Curricula. International Journal of Artificial Intelligence in Education, 33(2), 325–383.
https://doi.org/10.1007/s40593-022-00298-y

Williams, R., Park, H. W., Oh, L., & Breazeal, C. (2019). PopBots: Designing an Artificial Intelligence Curriculum for Early Childhood Education. Proceedings of the AAAI Conference on Artificial Intelligence, 33(01), 9729–9736.
https://doi.org/10.1609/aaai.v33i01.33019729

Wilson, M., Howell, C., Martin-Morales, K., & Park, S. (2023). Concept Mapping and Reading Comprehension. Journal of Political Science Education, 19(3), 408–431.
https://doi.org/10.1080/15512169.2023.2164861

Wojciechowski, A., & Korjonen-Kuusipuro, K. (2023). How artificial intelligence affects education? Human Technology, 19(3), 302–306.
https://doi.org/10.14254/1795-6889.2023.19-3.0

Wong, G. K. W., Ma, X., Dillenbourg, P., & Huan, J. (2020). Broadening artificial intelligence education in K-12. ACM Inroads, 11(1), 20–29.
https://doi.org/10.1145/3381884

Wood, L. J., Dautenhahn, K., Rainer, A., Robins, B., Lehmann, H., & Syrdal, D. S. (2013). Robot-Mediated Interviews - How Effective Is a Humanoid Robot as a Tool for Interviewing Young Children? PLoS ONE, 8(3), e59448.
https://doi.org/10.1371/journal.pone.0059448

Wu, N., & Wu, P. Y. (2024). Surveying the Impact of Generative Artificial Intelligence on Political Science Education. PS: Political Science & Politics, 57(4), 602–609.
https://doi.org/10.1017/s1049096524000167

Wu, S., & Han, S. (2023). System Evaluation of Artificial Intelligence and Virtual Reality Technology in the Interactive Design of Interior Decoration. Applied Sciences, 13(10), 6272.
https://doi.org/10.3390/app13106272

Xiaohong Yuan, Williams, K., McCrickard, S., Hardnett, C., Lineberry, L. H., Bryant, K., Jinsheng Xu, Esterline, A., Anyi Liu, Mohanarajah, S., & Rutledge, R. (2016). Teaching mobile computing and mobile security. 2016 IEEE Frontiers in Education Conference (FIE), 1–6. https://doi.org/10.1109/fie.2016.7757365

Yang, W. (2022). Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation. Computers and Education: Artificial Intelligence, 3, 100061. https://doi.org/10.1016/j.caeai.2022.100061

Yang, W., Hu, X., Yeter, I. H., Su, J., Yang, Y., & Lee, J. C. (2023). Artificial intelligence education for young children: A case study of technology-enhanced embodied learning. Journal of Computer Assisted Learning, 40(2), 465–477. Portico. https://doi.org/10.1111/jcal.12892

Yelland, N. J. (2018). A pedagogy of multiliteracies: Young children and multimodal learning with tablets. British Journal of Educational Technology, 49(5), 847–858. Portico. https://doi.org/10.1111/bjet.12635

Yin, R. K. (2014). Case study research: Design and methods (5th ed.). Sage.

Yu, L., & Yu, Z. (2023). Qualitative and quantitative analyses of artificial intelligence ethics in education using

Yu, Z., Xu, W., & Yu, L. (2022). Constructing an Online Sustainable Educational Model in COVID-19 Pandemic Environments. Sustainability, 14(6), 3598. https://doi.org/10.3390/su14063598

Yuskovych-Zhukovska, V., Poplavska, T., Diachenko, O., Mishenina, T., Topolnyk, Y., & Gurevych, R. (2022). Application of Artificial Intelligence in Education. Problems and Opportunities for Sustainable Development. BRAIN. Broad Research in Artificial Intelligence and Neuroscience, 13(1Sup1), 339–356. https://doi.org/10.18662/brain/13.1sup1/322

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(1). https://doi.org/10.1186/s41239-019-0171-0

Zingoni, A., Taborri, J., Panetti, V., Bonechi, S., Aparicio-Martínez, P., Pinzi, S., & Calabrò, G. (2021). Investigating Issues and Needs of Dyslexic Students at University: Proof of Concept of an Artificial Intelligence and Virtual Reality-Based Supporting Platform and Preliminary Results. Applied Sciences, 11(10), 4624. https://doi.org/10.3390/app11104624

Zourmpakis, A.-I., Kalogiannakis, M., & Papadakis, S. (2023). A Review of the Literature for Designing and Developing a Framework for Adaptive Gamification in Physics Education. The International Handbook of Physics Education Research: Teaching Physics, 5-1-5–26. https://doi.org/10.1063/9780735425712_005

Zourmpakis, A.-I., Kalogiannakis, M., & Papadakis, S. (2023). Adaptive Gamification in Science Education: An Analysis of the Impact of Implementation and Adapted Game Elements on Students' Motivation. Computers, 12(7), 143. https://doi.org/10.3390/computers12070143

Zourmpakis, A.-I., Kalogiannakis, M., & Papadakis, S. (2024). The Effects of Adaptive Gamification in Science Learning: A Comparison Between Traditional Inquiry-Based Learning and Gender Differences. Computers, 13(12), 324. https://doi.org/10.3390/computers13120324