Shiv Shakti International Journal of Multidisciplinary and Academic Research
ISSN: 2278-5973 (Online) | Vol. 13, No. 5, (September 2025)
https://doi.org/10.5281/zenodo.17019055

Emergent Role of Artificial Intelligence in Education: A View

Dr. T. Mahendran
Assistant Professor, KSR College of Education Tiruchengode, Namakkal, Tamil Nadu

Abstract

In today's educational landscape, computer technology has profoundly transformed multiple aspects of learning. Emerging technologies are making a substantial on the field of education, with Artificial Intelligence (AI), being one of the most prominent and widely adopted among these evolved computer technologies. The number of research studies centered around artificial intelligence has increased dramatically in recent years. This article's goal is to give readers a thorough grasp of how artificial intelligence (AI) is being used into teaching, learning and assessment procedures. This article aims to provide light on the current status of artificial intelligence (AI) in education and its consequences through the lens of recent empirical research. Additionally, the article identifies research gaps and presents potential future directions, which can be invaluable for policymakers and curriculum organizers.

Keywords: Artificial Intelligence, AI-enabled digital tools, AI-based technology, Intelligent Tutoring Systems, Personalized learning.

Introduction

In the current landscape, education has been transformed by technological advancements. The pandemic context of COVID-19 clearly demonstrates the importance and value of technology in education. Emerging technologies are very successful in the field of education. One rapidly developing technology that is widely used in teaching is artificial intelligence (AI) (Su and Yang, 2022). Furthermore, research is currently given a lot of attention in this subject (Ouyang, and Jiao, 2021). Likewise, several studies have been published that show the increasing trend of using artificial intelligence (AI) in education, or "AIEd".

Artificial Intelligence, also known as machine intelligence (Solanki, et.al.2021) or sometimes referred to as the digital brain (Holmes, Bialik, and Fadel, 2019), is associated with human intellectual capabilities such as reasoning, critical thinking, decision making is carried out by machines (Baker, and Smith, 2019: Guan, Mou and Jiang, 2020: Blake, Mathew, George, and Papakosta, 2021: Su and Yang, 2022). Artificial Intelligence is the study of creating machines or computers that can carry out tasks associated with human intellect, such as pattern recognition, speech and image recognition, language translation, and problem solving. (Chassignol et al., 2018; Chen et al., 2020).

Artificial Intelligence (AI) has assumed diver's roles within the educational process, serving as a tutor, a tutee, a learning tool, an assessment tool, and even an advisor for policymaking (Hwang, Xie, Wah and Gasevic, 2020). AI enhances the learning experience by offering personalized and interactive learning opportunities to students (Su and Yang, 2022: Zhang, and Aslan, 2021). With the assistance of AI applications, learners gain the ability to manage independently and direct their own educational journeys (Holmes, Bialik, and Fadel, 2019). Similarly, AI applications assist educators in identifying the learning challenges of students and adjusting their strategies to enhance the effectiveness of their teaching.

Corresponding Author: Dr. T. Mahendran, mahendrantedu@gmail.com

Therefore, the present article aimed to explore insights about the impacts of AI in personalized learning through the lens of recent empirical research.

Origin of Technology Integration in Education

Three main eras can be distinguished in the history of technology integration in education. The first period was called the pre-digital age, and it lasted from the 1890s until the 1970s during which radio and television technologies were incorporated into education. This period saw the broadcast of audio lectures and expert talks through these mediums. The second era, from the 1970s to the 1990s, was known as the personal computer age, marked by the introduction of computers into the learning process. The third and current era, which began in the 1990s and continues to the present day, is called the internet or digital age, characterized by the integration of personalized the integration of tutoring systems and online games into education has been noted by Howard and Mozejko (2015) and Leahy, Holand and Ward (2019).

The idea of utilizing machines in the educational process first emerged in the 1940s. Psychologists S. Pressey and B.F. Skinned were pioneers in the use of teaching machines for educational purposes. As observed by Holmes, Bialik, and Fadel (2019), machines were perceived as effective tools for learning and as personalized tutors. In the 1950s, Norman Crowder introduced a machine featuring a feedback design to help learners identify the causes of their errors. The 1960s and 1970s saw the development and adoption of Computer Aided Instruction (CAI) systems in educational institutions. CAI systems achieved widespread use in colleges, universities, and households and started to play a major role in many facets of learning with the advent of personal computers in the 1980s. Jaime Carbonell introduced an early CAI system, known as SCHOLAR, in 1970, implementing AI techniques (Chassignol, Khoroshavin, Klimova, and Bilyatdinova, 2018: Holmes, Bialik, and Fadel, 2019). In contrast to traditional CAI, this system created texts, questions, and answers based on an information network, saving teachers from having to prepare advance material. Intelligent Tutoring Systems – which are being used as AI applications in educating – were developed from this idea throughout time. Additionally, it has been demonstrated that Intelligent Tutoring Systems are superior teaching instruments to conventional classroom training (Ma, et.al., 2014: Chen, Wang, and Hsu, 2021).

The phrase 'Artificial Intelligence' was first created by John McCarthy in 1956 at the Dartmouth conference, which is widely recognized as the birthplace of AI. Prominent personalities such as Marvin Minsky, Alan Turing, Arthur Samuel, and Herbert Simon have all contributed significantly to the growth of Artificial Intelligence in education. In the early stages, computers were mainly used for basic learning tasks such as language acquisition and solving mathematical problems. (Russell, and Norvig, 2003). However, the rapid expansion of technology has led to the emergence of a variety of AI applications incorporated into education, including expert systems, adaptive learning systems, smart agents, deep learning, teaching robots, natural language processing and neural networks. (Chen, Xie, and Hwang, 2020).

Publication trends of Artificial Intelligence in Education

Researchers are increasingly interested in the integration of artificial intelligence into education. Numerous investigations have been undertaken in this sector, particularly between 2010 and 2019 (Chen et. al., 2020). Initially, we conducted a thorough search for relevant research materials, assessing publishing trends connected to AI in elementary and higher education. This search used a variety of databases, including Scopus, Web of Science, and Google Scholar, as well as keywords and phrases such as artificial intelligence, artificial neural networks, machine intelligence, deep learning, intelligent tutoring systems,

technology-enabled learning, and robotics. As a result, the researchers chose 47 research publications relevant to the current study and examined the publication trends within them.

Upon investigation, the study discovered a significant increase in the volume of papers relevant to AI applications in higher education since 2007. The number of articles increased from six in 2007 to 23 in 2018, out of 146 (ZawackiPlchter et al., 2019). Similarly, bibliometric research found a rise in the number of papers on AI in higher education indexed in the WOS and Scopus databases between 2007 and 2017 (Hinojo-Lucena et al., 2019). Furthermore, a recent research study examined 138 papers spanning from 2016 to 2022 within the domain of AI in higher education, revealing a two threefold rise in the number of publications compared to previous years. (Crompton, and Burke, 2023).

Furthermore, a systematic review study found that researchers are increasingly interested in exploring the field of teaching and learning AI-related topics, such as Generative AI, deep generative algorithms like variational auto encoders, and generative adversarial networks, within the K-12 school curriculum. This rise in interest was most noticeable between 2019 and 2021. The study also revealed that the maximum number of articles (17) appeared in the year 2021, with data gathered from digital databases such as the ACM Digital Library, IEEE Xplore, ProQuest (which includes ERIC, IBSS, PsycINFO), Scopus, and Web of Science. (Rizvi, Waite, and Sentence, 2023). It is presented in Figure 1:

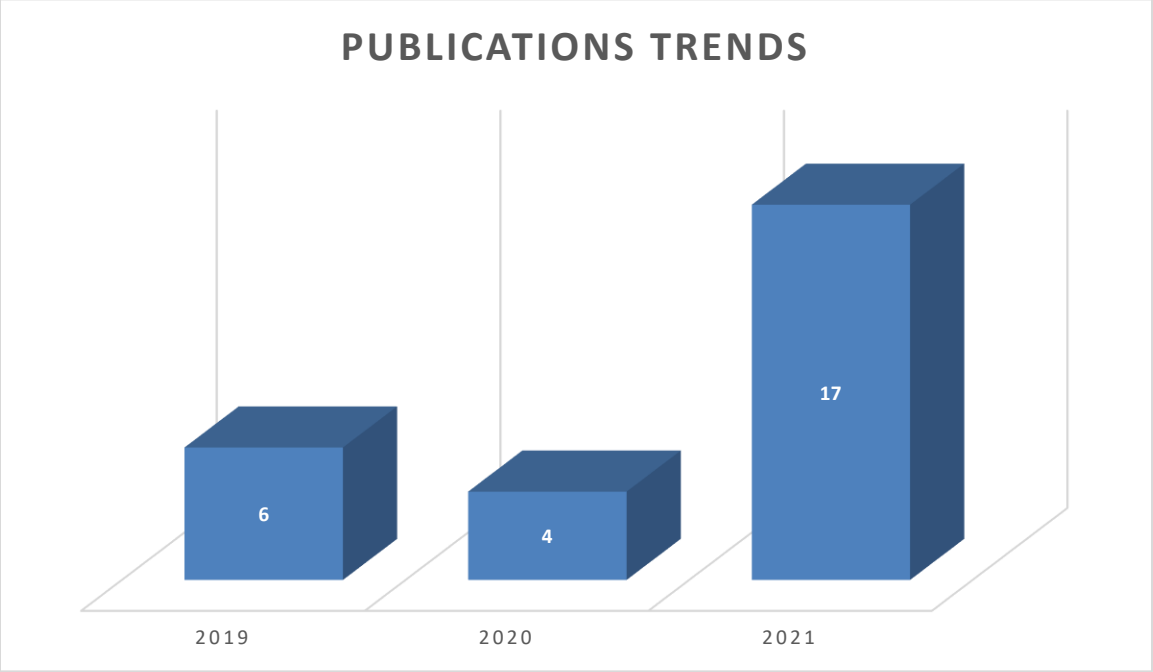

Figure 1- Publication trends related to AI in K-12 school level

Additionally, a research study examined 143 articles pertaining to AI in education and observed a substantial surge in AI-related publications during the period of 2010 to 2019 (Chen, Xie and Hwang, 2020). Notably, the highest number of publications was recorded in the year 2019, as depicted in Figure 2. This finding was corroborated by Namatherdhala, Maazher, and Sriram (2022) and further supported by Chen et al. (2020). Furthermore, there has been a noteworthy upswing in research interest surrounding

ChatGPT, an AI-based language tool, in recent years. Up until March 2023, over 3,000 articles related to ChatGPT have been published across a variety of journals, conferences, and media reports (Ray, 2023).

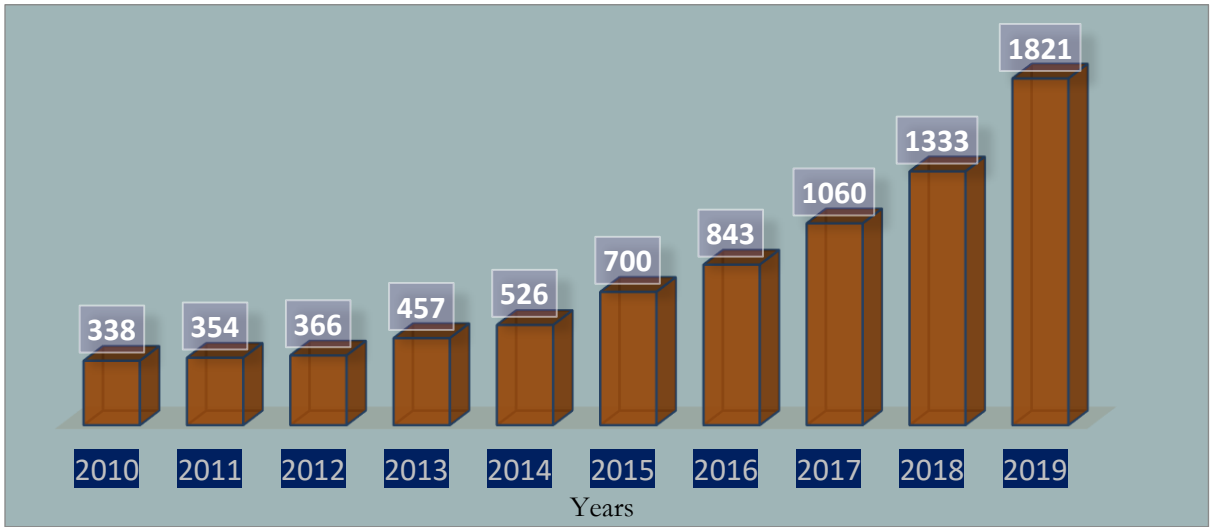

Figure 2- Publication Trends related on AI in Education
(Source: Extracted from Chen, Xie, and Hwang, 2020)

Artificial intelligence's usefulness in the educational process

Education typically encompasses three fundamental processes: teaching, learning, and assessment. In this section, the researchers have categorized the significant role of Artificial Intelligence in education, based on empirical research, into three key domains: 1. Utilizing AI in teaching, 2. Enhancing learning through AI, and 3. AI-enabled assessment.

1. Utilizing AI in teaching

The application of AI in teaching has been found to improve students' academic progress (Zhao et al., 2019). The successful integration of AI into education is heavily dependent on instructors' attitudes and acceptance of technology adoption in the classroom. According to studies, teachers have demonstrated a high degree of acceptability and trust in using technology-based apps for teaching, particularly in response to the COVID-19 epidemic (Al Darayseh, 2023). Educators are increasingly interested in using AI-based technology in the classroom, particularly smart learning portals and chatbots (Al Darayseh, 2020: Topal, Eren, and Gecer, 2021).

In addition, intelligent tutors or instructional agents have emerged as useful resources for increasing learners' performance (Zhang, and Aslan, 2021). Notably, robots have been used as instructional agents to encourage meaningful interactions and participation in the learning process (Kim, 2018: Kewalramani, Kidman, and Palaiologou, 2021). Furthermore, multiple studies have shown that AI applications perform better as instructors than traditional teachers. For example, intelligent tutoring systems have successfully assumed the function of tutors in teaching numerous disciplines such as language, mathematics, physics

and commuter science. (Mahmoud, and Hamayed 2016: Zhang, and Jia, 2017). These systems provide one-on-one teaching similar to a drill and practice method (McArthur, Lewis, and Bishay, 2005: VanLehn, 2011). Furthermore, intelligent tutoring systems generate interactive learning environments in which students receive constant feedback and mentorship rather of feedback only after completing a task (Chassignol et al., 2018). Similarly, using intelligent tutoring systems has been linked to higher levels of student accomplishment when compared to traditional classroom education and the usage of printed materials. (Ma, et al., 2014).

In recent times, AI-based tools have significantly aided educators in the preparation of their educational materials, including content, lecture notes, and handouts. Teachers can easily produce video courses, slideshows, and written materials using these resources. For instance, Jasper is an AI-driven tool that offers a range of writing services (Namatherdhala, Maazher, and Sriram, 2022). Furthermore, a large number of AI-based solutions, such as ChatGPT and Gemini, are now accessible to generate learning content, including individualized learning materials, lesson plans, teaching methodologies, and classroom management approaches for teachers, (Ray, 2023). Similarly, various AI tools, including Pictory.ai, Steve.ai, Flexclop.ai, and others, are employed to transform text and images into learning videos.

2. Enhancing learning through AI:

Several studies have showcased the improvement in learners' educational experiences facilitated by AI applications. AI-powered tools offer customized learning experiences tailored to the specific requirements and learning pace of individual students (Hutchins, 2017). These tools can predict and provide appropriate learning materials based on each learner's capabilities, allowing both advanced and slower learners to progress at their own individual rates. In addition, these AI tools effectively motivate and engage learners in their educational activities (Chen, Xie, Zou and Hwang, 2020).

Numerous research investigations have suggested that the primary AI-driven tools are designed for language and mathematical topics, predominantly targeting primary and secondary school levels, (Chen, Xie, Zou and Hwang, 2020). In particular, AI-driven digital tools have proven effective in enhancing students' English language skills, encompassing reading, writing and comprehension. For instance, a large-scale study demonstrated that AI-powered multi-sensory technology has a positive impact on the reading and comprehension skills of primary-level students studying English (Srinivasan, and Murthy, 2021). Another study revealed that an AI-based poetry machine contributes to the improved poetry-writing abilities of high school students (Kangasharju, Ilomaki, Lakkala and Toom, 2022).

Additionally, Chatbots, including Open AI's offerings such as Google's Gemini, Facebook's Meta AI, and Microsoft's ChatGPT, are capable of generating human-like language and can promptly address basic queries on a variety of topics, thereby improving the availability of essential knowledge (Alqahtani, and et al. 2023). In particular, ChatGPT holds the potential to deliver tailored learning experiences for students by considering their learning preferences, strengths, and areas for improvement. Additionally, ChatGPT can assist students in enhancing their language proficiency (Ray, 2023).

Furthermore, sustaining student engagement is essential for keeping them actively involved in the learning process. While many researchers have proposed various strategies to increase learner engagement, Diwan et al. (2023) introduced an AI-driven approach that generates automatic learning content using a natural language generation model based on the pre-trained language model GPT-2. Their efforts produced promising and encouraging outcomes.

3. AI-enabled assessment

Assessment holds a crucial role in comprehending learners' educational progress and achievements within educational environments (Chen, Wang, and Hsu, 2021). AI-driven assessment tools aid educators in identifying learning challenges and performance gaps among their students (Chassignol, Khoroshavin, Klimova, and Bilyatdinova, 2018). Intelligent evaluating systems enable teachers to adapt their teaching tactics and approaches based on their students' learning patterns (Yang, Ogata, Matsui, and Chen, 2021). According to studies, instructors provide learning materials such as textbooks, pre-prepared scripts, and textual content for smart evaluation. AI technology extracts key concepts from these textual materials and automatically generate evaluation questions alongside reference answers.

The test questions are presented in various formats, including multiple-choice, yes or no, fill in the blanks, and short answer or essay types of questions (McDermott, Agarwal, D'Antonio, Roediger, and McDaniel, 2014). AI technology assesses students' responses by comparing them to pre-prepared answers and offers feedback. Even in cases where students provide handwritten responses, AI technology can recognize and convert the handwritten characters from scanned images into readable text (Alhajj, and Polat, 2003: Al-Dmour, and Zitar, 2007: Elnagar, and Harous, 2010: Haraty, and El-Zabadani, 2015: Li, 2017). Additionally, learners can improve their memory retention and grasp of the learning materials through feedback and repetitive practice (Yang, Ogata, Matsui and Chen, 2021). Furthermore, AI technology provides fast feedback, which improves students' learning performance (Cavalcanti, and et al., 2021).

Furthermore, AI technology finds application in evaluating the effectiveness of teaching by analyzing learners' engagement and their emotional responses, including emotions like happiness and sadness, during classroom sessions (Ge, Wand, and Liu, 2021: Fomichov, and Fomichova, 1995: Chung, So, Choi, Yan, Wong, 2021). For instance, a study sought to gauge learners' engagement in the classroom as a means of assessing the quality of lectures. The study's findings indicated that AI-enabled technology effectively assessed learners' attention by analyzing facial expressions, including face landmarks, eye gaze movement, and head positioning during teaching (Mohammadreza and Safabakhsh, 2021).

Key Challenges

Research has identified the challenges that both teachers and students have when implementing Artificial Intelligence into their teaching and learning processes, particularly given its novelty to them. For instance, Crompton, et al. (2022) pointed out issues such as negative precessions, a lack of technological skills among students and teachers, usability concerns, and challenges related to the design of AI tools in the context of K-12 education. Similarly, a study suggested that teaching AI concepts to K-12 pupils with insufficient computing backgrounds can cause confusion and learning challenges, in contrast to the generally smoother learning process for university students. (Lyu, Z., Ali, S., &Breazeal, C., 2021).

Even when educational institutions have the essential resources and facilities in place, the readiness and competence of teachers concerning AI play a pivotal role in its successful primary school teachers who teach AI curriculum and evaluated their competences in AI-focused educational environments. The study found that teachers frequently experience anxiety when developing and implementing AI curricula due to a lack of confidence in their comprehension of AI ideas and principles. (Lim, K., and K won, K., 2023).

Concluding Remarks

The major goal of AI technology in education is to enable the successful delivery of personalized learning experiences based on each learner's unique features and skills. Personalized learning has shown itself to

be an effective strategy, and it is frequently used in educational institutions. Recent research in the subject of AI in education (AIEd) has found persuasive evidence that AI technology can improve individualized learning for pupils. Similarly, AI technology benefits learners by facilitating deep learning, collaborative learning, and continuous and comprehensive evaluation. Additionally, it serve4d as a learning partner. (Bbarbhuniya, 20230. Moreover, it is essential to conduct more research in the areas of teaching, learning, and assessment across primary, secondary, and higher education levels to ensure the successful integration of AIEd.

Furthermore, recent research has identified two major challenges that must be addressed before AIEd can be used effectively. First, there is a disconnect between educational theories and models and the practical application of AI technologies in real- world educational settings (Zhang and Aslan, 2021: Tang, Chang, and Hwang, 2021: Kabudi, Pappas: and Olsen, 2021). Second, there is a shortage of AI applications for a wide range of areas other than English, mathematics, chemistry, and programming (Chen, Xie, and Hwang, 2020), and physics (Tan and Cheah, 2021).

To address these challenges, stakeholder4s and educators should work together to raise awareness about the benefits of AI in education and dispel misconceptions and negative attitudes toward AI technology. Additionally, educational institutions should allocate and distribute resources to acquire the necessary equipment for the effective implementation of AIEd.

References

Al Darayseh, A. (2020). The impact of COVID-19 pandemic on modes of teaching science in UAE schools. *Journal of Education and Practice*, 11(20), 110–115.

Al Darayseh, A. (2023). Acceptance of Artificial Intelligence in teaching science: Science teachers' perspective. *Computers and education: Artificial intelligence*, 4, 100132. https://doi.org/10.1016/j.caeai.2023.100132.

Al-Dmour, A., &Zitar, R.A. (2007). Arabic writer identification based on hybrid spectral–statistical measures, *Journal of Experimental & Theoretical Artificial Intelligence*, 19(4), 307-332. https://doi.org/0.1080/09528130701228800.

Alhajj, R., &Polat, F. (2003). Multiple agents to identify and separate touching digits in unconstrained handwritten Hindi numerals. *Journal of Experimental & Theoretical Artificial Intelligence*, 15(4), 461-471, https://do.org/10.1080/09528130310001611586.

Ali, S., DiPaola, D., Lee, I., Sindato, V., Kim, G., Blumofe, R., & Breazeal, C. (2021). Children as creators, thinkers, and citizens in an AI-driven future. Computers and Education: Artificial Intelligence, 2, 1-11. https://doi.org/10.1016/j.caeai.2021.100040.

Alqahtani, T , Badreldin H.A., Alrashed, M., Alshaya, A.I., Alghamdi, S.S., Saleh, K.B., Alowais, S.A., Alshaya, O.A., Rahman, I., Al Yami, M.S., &Albekairy, A.M. (2023). The emergent role of artificial intelligence, natural learning processing, and large language models in higher education and research. Research in social and administrative pharmacy. https://doi.org/10.1016/j.sapharm.2023.05.016.

Baker, T., & Smith, L. (2019). Educ-AI-tion rebooted? Exploring the future of artificial intelligence in schools and colleges. Retrieved from Nesta Foundation website https://media.nesta.org.uk/documents/Future_of_AI_and_education_v5_WEB.pdf.

Barbhuiya, R.K. 2023). Introduction to Artificial Intelligence: Current developments, concerns and possibilities for education. *Indian journal of educational technology,*5(2), 266-277.

Blake, R.W., Mathew, R., George, A., &Papakosta, N. (2021). Impact of Artificial intelligence on engineering: Past, Present and Future. *Procedia CIRP*, 1728-1733. http://doi.org/10.1016/j.procir.2021.11.291.

Cavalcanti, A.P., Barbosa, A., Carvalho, R., Freitas, F., Tsai, Y.S., Gasevic, D., &Mello, R.F. (2021). Automatic feedback in online learning environments: A systematic literature review. *Computers and education: Artificial intelligence* 2, 100027. https://doi.org/10.1016/j.caeai.2021.100027.

Chassignol, M., Khoroshavin, A., Klimova, A., &Bilyatdinova, A. (2018). Artificial intelligence trends in education: a narrative overview. *Procedia computer science,* 136, 16-24. http://doi.org/10.1016/j.procs.2018.08.233.

Chassignol, M., Khoroshavin, A., Klimova, A., and Blyatdinova, A. (2018). Artificial intelligence trends in education: a narrative overview. Procedia computer science, 136, 16-24. https://doi.org/10.1016/j.procs.2018.08.233.

Chen, C.M., Wang, J.Y., &Hsu, L.C. (2021). An interactive test dashboard with diagnosis and feedback mechanisms to facilitate learning performance. *Computers and education: Artificial intelligence*, 2, 100015. https://doi.org/10.1016/j.caeai.2021.100015.

Chen, X., Xie, H., &Hwang, G.J. (2020). A multi-perspective study on artificial intelligence in education: grants, conferences, journals, software tools, institutions, and researchers. *Computers and education: Artificial intelligence*, 100005, 1-20. https://doi.org/10.1016/j.caeai.2020.100005.

Chen, X., Xie, H., Zou, D., & Hwang, G. (2020). Application and theory gaps during the rise of artificial intelligence in education. *Computers & Education: Artificial Intelligence*, 1, 100002. https://doi.org/10.1016/j.caeai.2020.100002.

Chen, X., Xie, H., Zou, D., &Hwang, G.J. (2020). Application and theory gaps during the rise of artificial intelligence in education. *Computers and education: Artificial intelligence*, 1, 100002, 1-20. https://doi.org/10.1016/j.caeai.2020.100002.

Chung, J.W.Y., So, H.C.F., Choi, M.M.T., Yan, V.C.M., &Wong, T.K.S. (2021). Artificial intelligence in education: Using heart rate variability as a biomarker to assess emotions objectively. *Computers and education: Artificial intelligence*, 2, 100011.https://doi.org/10.1016/j.caeai.2021.100011.

Crompton, H., & Burke, D. (2022). Artifcial intelligence in K-12 education. SN Social Sciences, 2, 113. https://doi.org/10. 1007/s43545-022-00425-5.

Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International journal of educational technology in higher education*, 20, 1-22. https://doi.org/10.1186/s41239-023-00392-8.

Crompton, H., Jones, M., & Burke, D. (2022). Afordances and challenges of artifcial intelligence in K-12 education: A systematic review. Journal of Research on Technology in Education. https://doi.org/10.1080/15391523.2022.2121344.

Diwan, C., Srinivasa, S., Suri, G., Agarwal, S., & Ram, P. (2023). AI- based learning content generation and learning pathway augmentation to increase learner engagement. *Computers and education: Artificial intelligence*, 4, 100110. https://doi.org/10.1016/j.caeai.2022.100110.

Elnagar, A. &Harous, S. (2010). Recognition of handwritten Hindu numerals using structural descriptors. *Journal of Experimental & Theoretical Artificial Intelligence*, 15:3, 299-314, http://doi.org/10.1080/0952813021000047170.

Fomichov, V. A., &Fomichova, O. S. (1995). The artificial intelligence theory and highly effective methods of teaching young children foreign languages. *Cybernetica*, 38(4), 321–344.

Ge, D., Wang, X., & Liu, J. (2021). A teaching quality evaluation model for preschool teachers based on deep learning. *International Journal of Emerging Technologies in Learning,* 16(3), 127–143. https://doi.org/10.3991/ijet.v16i03.20471.

Gero, J.S. (1996). Special issue: Artificial intelligence in computer aided design – progress and prognosis. *Computer aided design*, 28(3), 153-154.

Guan, C., Mou, J., &Jiang, Z. (2020). Artificial intelligence innovation in education: A twenty-year data-driven historical analysis. *International journal of innovation studies*, 4, 134-147. https://doi.org/10.1016/j.ijis.2020.09.001.

Haraty, R.A., & El-Zabadani, H.M. (2015). Abjad Hawwaz: An Offline Arabic Handwriting Recognition System. *International Journal of Computers and Applications*, 27(3), 178-189, https://doi.org/10.1080/1206212X.2005.11441767.

Hinojo-Lucena, F., Arnaz-Diaz, I., Caceres-Reche, M., & Romero-Rodriguez, J. (2019). A bibliometric study on its impact the scientifc literature. Education Science. https://doi.org/10.3390/educsci9010051.

Holmes, W., Bialik, M., &Fadel, C. (2019). *Artificial intelligence in Education: Promises and Implications for teaching and learning*. The centre for curriculum redesign, Boston, USA.

Howard, S. K., &Mozejko, A. (2015). Considering the history of digital technologies in education. In M. Henderson, & J. Romeo (Eds.). *Teaching and digital technologies: Big issues and critical questions* (pp. 157–168). Port Melbourne, Australia: Cambridge University Press.

Hutchins D. (2017). AI Boosts Personalized Learning in Higher Education. Educational technology. Retrieved from https://edtechmagazine.com/higher/article/2017/11/ai-boosts-personalized-learning-higher-education.

Hwang, G.J., Xie, H., Wah, B.W., &Gasevic, D., (2020). Vision, Challenges, roles and research issues of artificial intelligence in education. *Computers and education: Artificial intelligence*, 1, 100001, 1-5. https://doi.org/10.1016/j.caeai.2020.100001.

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-enabled adaptive learning systems: A systematic mapping of literature. *Computers and education: Artificial intelligence* 2, 100017.https://doi.org/10.1016/j.caeai.2021.100017.

Kangasharju, A., Ilomaki, L., Lakkala, M., & Toom, A. (2022). Lower secondary students' poetry writing with the AI-based poetry machine. *Computers & Education: Artificial Intelligence*, 3, 100048. https://doi.org/10.1016/j.caeai.2022.100048.

Kangasharju, A., Ilomaki, L., Toom, A., Lakkala, M., Kantosalo, A., &Toivonen, H. (2021). Lower secondary students' learning to write poems with the support of the Poetry Machine. *The Journal of Literacy and Technology*, 22(1).

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.

Kim M. (9th Feb 2018).The social robot teacher. Retrieved from https://bold.expert/the-social-robot-teacher/.

Kim, K., and Kwon, K. (2023). Exploring the AI competencies of elementary school teachers in South Korea. *Computers and education: Artificial intelligence*, 4, 100137. https://doi.org/10.1016/j.caeai.2023.100137.

Korshunov, P., & Marcel, S. (2018). Deepfakes: A new threat to face recognition? Assessment and detection. arXiv preprint arXiv:1812.08685 (2018). In Ali, S., DiPaola, D., Lee, I., Sindato, V., Kim, G., Blumofe, R., & Breazeal, C. (2021). Children as creators, thinkers, and citizens in an AI-driven future. *Computers and Education: Artificial Intelligence*, 2, 1-11. https://doi.org/10.1016/j.caeai.2021.100040.

Leahy, S.M., Holand, C., &Ward, F. (2019). The digital frontier: Envisioning future technologies' impact on the classroom. *Futures*, 113, 102422. https://doi.org/10.1016/j.futures.2019.04.009.

Li, S. (2017). Handwritten character recognition technology combined with artificial intelligence, *Journal of Discrete Mathematical Sciences and Cryptography*, 20:1, 167-178, doi: https://doi.org/10.1080/09720529.2016.1178914.

Lyu, Z., Ali, S., & Breazeal, C. (2021). Introducing variational autoencoders to high school students. ArXiv Preprint ArXiv:2111.07036.

Ma W. et al.(2014). Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis. J. Educ. Psychol. In Chassignol, M., Khoroshavin, A., Klimova, A., and Bilyatdinova, A. (2018). Artificial intelligence trends in education: a narrative overview. *Procedia computer science*, 136, 16-24. http://doi.org/10.1016/j.procs.2018.08.233.

Ma, W., Adesope, O., Nesbit, J.C., & Liu, Q. (2014). Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis. Journal of Educational Psychology, 106(4), 901-918.

Mahmoud M.H., & Abo El-Hamayed S.H. (2016). An intelligent tutoring system for teaching the grammar of the Arabic language. *J. Electr. Syst. Inf. Technology*.

McArthur, D., Lewis, M., &Bishay, M. (2005). The roles of artificial intelligence in education: Current progress and future prospects. *I-Manager's Journal of educational technology*, 1(4), 42- 80.

McDermott, K. B., Agarwal, P. K., D'Antonio, L., Roediger, H. L., III, & McDaniel, M. A. (2014). Both multiple-choice and short-answer quizzes enhance later exam performance in middle and high school classes. *J. Exp. Psychol. Appl.*, 20(1), 3.

Mohammadreza, E., &Safabakhsh, R. (2021). Lecture quality assessment based on the audience reactions using machine learning and neural networks. *Computers and education: Artificial intelligence,* 2, 100022. https://doi.org/10.1016/j.caeai.2021.100022.

Namatherdhala, B., Maazher, N., and Sriram, G.K. (2022). A comprehensive overview of artificial intelligence trends in education. *International research journal of modernization in engineering technology and science*, 4(7), 1-5.

Ouyang, F., &Jiao, P. (2021). Artificial Intelligence in education: The three paradigms. *Computers and education: Artificial intelligence*, 2, 100020, 1-6. https://doi.org/10.1016/j.caeai.2021.100020.

Ouyang, F., Zheng, L., & Jiao, P. (2022). Artifcial intelligence in online higher education: A systematic review of empirical research from 2011–2020. Education and Information Technologies, 27, 7893–7925. https://doi.org/10.1007/ s10639-022-10925-9.

Ray, P.P. (2023). ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. Internet of Things and Cyber-physical systems, 3, 121-154. https://doi.org/10.1016/j.iotcps.2023.04.003.

Rizvi, S., Waite, J.,and Sentence, S. (2023). Artificial intelligence teaching and learning in k-12 from 2019 to 2021: A systematic literature review. *Computers and education: Artificial intelligence*, 4, 100145. https://doi.org/10.1016/j.caeai.2023.100145.

Russell, S.J., &Norvig, P. (2003), *Artificial Intelligence: A Modern Approach* (2nd ed.), Upper Saddle River, New Jersey: Prentice Hall, ISBN 0-13-790395-2.

Solanki, S. L., Pandrowala, S., Nayak, A., Bhandare, M., Ambulkar, R. P., &Shrikhande, S. V. (2021). Artificial intelligence in perioperative management of major gastrointestinal surgeries. *World Journal of Gastroenterology: WJG*, 27(21), 2758–2770. https://doi.org/10.3748/wjg.v27.i21.2758.

Srinivasan, V., & Murthy, H. (2021). Improving reading and comprehension in K-12: Evidence from large scale AI technology intervention in India. *Computers and education: Artificial intelligence*, 2, 100019.https://doi.org/10.1016/j.caeai.2021.100019.

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

Tan, D.Y., &Cheah, .W. (2021). Developing a gamified AI-enabled online learning application to improve students' perception of university physics. *Computers and education: Artificial intelligence* 2, 100032.https://doi.org/10.1016/j.caeai.2021.100032.

Tang, K. Y., Chang, C. Y., & Hwang, G. J. (2021). Trends in artificial intelligence supported e-learning: A systematic review and co-citation network analysis (1998–2019). *Interactive learning environments*, 1–19.

Topal, A. D., Eren, C. D., &Geçer, A. K. (2021). Chatbot application in a 5th grade science course. *Education and Information Technologies,* 26(5), 6241–6265. https://doi.org/ 10.1007/s10639-021-10627-8.

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, 46(4), 197–221.

Wolf, M. J., Miller, K. W., &Grodzinsky, F. S. (2017). Why we should have seen that coming: Comments on Microsoft's Tay "experiment" and wider implications. *The ORBIT Journal*, 1(2), 1–12. https://doi.org/10.29297/orbit.v1i2.49.

Yang, J.H., Ogata, H., Matsui, T., & Chen, N.S., (2021). Human-centered artificial intelligence in education: Seeing the invisible through the visible. *Computers and education: Artificial intelligence*, 2, 100008.https://doi.org/10.1016/j.caeai.2021.100008.

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), 1–27. https://doi.org/10.1186/s41239-019-0171-0.

Zhang B.,&Jia J. (2017). Evaluating an intelligent tutoring system for personalized math teaching. Proceedings - 2017 International Symposium on Educational Technology, ISET.

Zhang, K., & Aslan, A.B. (2021). AI technologies for education: Recent research & future directions. *Computers and education: Artificial intelligence*, 2, 100025.https://doi.org/10.1016/j.caeai.2021.100025.

Zhao, L., Chen, L., Liu, Q., Zhang, M., & Copland, H. (2019). Artificial intelligence-based platform for online teaching management systems. *Journal of Intelligent and Fuzzy Systems*, 37(1), 45–51.