ARTIFICIAL INTELLIGENCE AND THE FUTURE OF SMART EDUCATION

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ABSTRACT

With the rapid development of global science and technology, artificial intelligence (AI) has increasingly penetrated the education sector and transformed traditional teaching and learning processes. This study aims to assess the impact of AI on education through a qualitative research approach based on literature review. Journal articles, professional publications, and conference reports were analyzed to examine the application and effects of AI in educational institutions. The findings indicate that AI has been widely adopted in administration, instruction, and learning. Applications such as automatic grading systems, intelligent tutoring systems, virtual teachers, adaptive learning, personalized learning, intelligent campus management, and distance learning have significantly improved teaching efficiency and enhanced student learning experiences. AI technologies including machine learning, natural language processing, and computer vision enable customized learning paths, real-time feedback, and data-driven decision-making. However, the integration of AI also presents challenges such as ethical concerns, data privacy issues, digital divide, infrastructure limitations, and the need for teacher training. Overall, AI has a profound impact on education and will continue to promote innovation, improve teaching quality, and support diversified and personalized learning in the future.

Keywords

Education, artificial intelligence, leaner, Educational Technology, Teaching Reform, Smart Education, Digital Learning Ecosystem

1. INTRODUCTION

At present, with the rapid development of global science and technology, artificial intelligence (AI) has improved by leaps and bounds and is continuously updated and widely used in various fields (Pannu, 2015). It is an indisputable fact that AI has increasingly penetrated the educational environment and teaching processes of schools. In the process of development, more and more attention has been paid to the importance of this technology in the field of education.

AI has been widely applied in education and has demonstrated substantial application advantages, exerting a profound impact on the teaching process and classroom management (Chassignol, Khoroshavin, Klimova, & Bilyatdinova, 2018; Roll & Wylie, 2016). It can continuously optimize and improve the learning environment, stimulate students' enthusiasm, initiative, and creativity (Colchester, Hagras, Alghazzawi, & Aldabbagh, 2017; Yang & Bai, 2020), and significantly enhance classroom management efficiency, ensuring that it becomes more systematic and effective (Tuomi, 2018; Wang, 2020).

With the advancement of modern science and technology, research results in related fields have enabled AI to be further integrated into education, showing sound application effects and contributing to teaching reform. The integration of AI has realized closer coordination between

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teaching and learning processes, while also providing new opportunities for innovation in educational practices.

However, although AI has shown significant advantages in education, it is necessary to systematically analyze its applications, impact, and challenges to understand its overall influence on contemporary education systems. Therefore, this study comprehensively summarizes and analyzes the application of AI in education, focusing on its role in enhancing teaching quality, learning effectiveness, classroom management, and future educational development.

2. ARTIFICIAL INTELLIGENCE IN CURRENT EDUCATION

The mention of artificial intelligence brings to mind a super computer, a computer with immense processing capabilities, including adaptive behavior, such as inclusion of sensors, and other capabilities, that enable it to have human-like cog nition and functional abilities, and indeed, which improve the supercomputers interaction with human beings. Indeed, different motion pictures have been made to showcase the abilities of AI, such as in smart buildings, such as the ability to manage air quality in a building, temperatures, and or playing music depending on the sensed mood of the occupants of the space. Within the education sector, there has been increased application of artificial intelligence, going over and above the conventional understanding of AI as a supercomputer to include embedded computer systems. For example, embedded into robots, AI, or computers and supporting equipment enable the creation of robots that improve the learning experience of the student, from the most basic unit of education, early childhood education. Indeed, Timms posited that cobots or the application of robots, working together with teachers or colleague robots (cobots) are being applied to teach children routine tasks, including spelling and pronunciation and adjusting to the stu dents' abilities Similarly, the web-based and online education, as enumerated in different studies, has transi tioned from simply availing materials online or on the web for students to simply download, study, and do assignments to just pass, to include intelligent and adaptive web-based systems that learn instructor and learner behavior to adjust accordingly, to enrich the educational experience . Artificial intelligence in education, according to Chassignol et al. has been incorporated into administration, instruction or teaching, and learning . These areas, which Chassignol et al. identify as the framework for analyzing and understanding artificial intelligence in education, will form the scope of this study. The application of AI algorithms and systems in education are gaining increased interest year by year. Fig. 1 shows the rising number of papers published in the topics ''AI'' and ''Education'' from Web of Science and Google scholar since 2010. Note that the papers published in 2015-2019 accounted for a large proportion, i.e., 70% of all the papers.

In addition, artificial intelligence in contemporary education extends beyond robots and web-based systems to encompass intelligent tutoring systems, learning analytics platforms, and data-driven decision-support mechanisms. These advanced systems assist educators and administrators in making evidence-based decisions by analyzing extensive volumes of student data. Through the identification of learning patterns, prediction of academic performance, and early detection of at-risk students, AI facilitates timely interventions and enhances overall academic outcomes. Consequently, this data-driven approach strengthens instructional planning while simultaneously improving institutional governance and strategic management.

Furthermore, the integration of core AI technologies, including natural language processing, machine learning, and computer vision, has fundamentally transformed classroom interaction and assessment practices. These technologies enable automated evaluation, real-time monitoring of learner engagement, and the delivery of personalized instructional content aligned with individual

learning needs. As a result, AI enhances operational efficiency within educational institutions while promoting a more inclusive, adaptive, and learner-centered educational framework.

With the ongoing advancement of AI research and technological innovation, educational institutions worldwide are increasingly adopting intelligent systems to remain competitive and responsive to the evolving requirements of 21st-century education. This progressive integration underscores the strategic significance of artificial intelligence in shaping the future trajectory of global education systems.

3. THE APPLICATION ASPECTS OF ARTIFICIAL INTELLIGENCE IN EDUCATION

With the development of artificial intelligence technology, modern education will be combined with more technologies, such as speech semantic recognition, image recognition, Augmented Reality / Virtual Reality, machine learning, brain neuroscience, quantum computing, blockchain and so on. These technologies are collectively referred to as intelligent technologies and are consistently and rapidly integrated with the education industry. The intelligent upgrade of the education industry is in full swing. At present, more and more artificial intelligence education products have been applied to school education. (Yan, 2017). The typical scenarios of artificial intelligence education applications include intelligent tutor-assisted personalized teaching and learning, intelligent assistants such as educational robots, children's partners at home, intelligent assessment, mining and intelligent analysis of educational data, learning analysis and learning, digital portraits, and etcetera. Literature studies show that artificial intelligence technology in education has been used in at least 10 aspects: the (i) automatic grading system, (ii) interval reminder, (iii) teacher’s feedback, (iv) virtual teachers, (v) personalized learning, (vi) adaptive learning, (vii) augmented reality / virtual reality, (viii) accurate reading, (ix) intelligent campus and (x) distance learning.

3.1. The Automatic Grading System

The automatic grading system is an artificial intelligence based professional computer program that simulates the behavior of a teacher to assign grades to student tasks in an educational setting. It assesses student knowledge, the program analyzes their answers, provides feedback and develops personalized training programs. Many artificial intelligence education apps are using this program. Through the test of learning, the system automatically provides the learner evaluation score. This method can help teachers to better understand the learning situation of their students, and students, on the other hand, are made more aware of their level of learning achievement and knowledge mastery. One of the examples of the automatic grading system used in education app is Wolfie, an Israeli music education application (Shang, 2019). This app focuses more on classroom teaching, providing teaching and evaluation tools for teachers and students, and using modern advanced technology to change all aspects of music education, from teaching to learning to practice. The automatic grading system in Wolfie helps music educators guide students to correct the mistakes in the exercises, and provide teachers and students with a completely different way of music education and learning interaction.

3.2. Interval Reminder

When someone is about to forget his/her knowledge, revising the knowledge is an effective technical solution that reinforces understanding and memory through timed repetitive reminders. The Polish inventor Peter Wozniak proposed an educational app based on the effects of the interval (Nazemi, Breyer, Burkhardt, Stab & Kohlhammer, 2014). This app tracks what people

have learned and when. Using artificial intelligence, the app can determine when someone is most likely to forget something and suggest for him/her to modify it. Just a few reminder revisions will ensure that the information is now stored in a human's brain for years.

Teacher feedback is the student assessment of the teacher, a feedback method that has existed in education for some time. Despite the shift from paper to online surveys, little to no progress has been made in the feedback area (Holstein, McLaren & Aleven, 2019). Since student evaluation of teaching is often the most valuable source of information, it obviously needs to be elevated. Modern technologies, such as artificial intelligence-driven conversation robots, machine learning and natural language processing, provide exciting opportunities to improve the quality of feedback (Peters, 2019). Chat robot, for example, can collect opinions through a conversational interface like a real interviewer and only needs a small amount of work by others. The conversation can be adjusted based on student answers and personality.

3.3. Virtual Classroom

The development of virtual reality (VR), augmented reality (AR), hearing and sensing technologies is conducive to the reform of teaching environment. Utilize ubiquitous computing technology to realize the integration of physical space and virtual space to create virtual classrooms and virtual laboratories. Virtual classrooms use virtual technology to simulate teaching scenes that are difficult to explain, and for natural phenomena or changes in things that cannot be observed or hard to observe in real life, it can be presented in a smart classroom to create a contextual learning environment for students. Multi-dimensional presentation of learning content, mobilizing students' vision, hearing, and other senses to participate, allowing students to feel a strong sense of reality, it makes abstract concepts and theories more intuitive and visualized, stimulate students' interest in learning, and improve teaching effects. The hybrid virtual classroom is very promising regarding flexibility in course attendance since students can choose to come to the campus or to attend the lecture at home. Virtual simulation laboratory refers to the virtual reproduction of real experimental scenes through 3D modeling with the help of multimedia, simulation and virtual reality technologies, create related software and hardware operating environments on the computer that can assist, partially replace or even replace all the operating links of traditional experiments. By constructing a highly simulated virtual experimental environment and experimental operating objects, and with the help of advanced somatosensory interactive equipment for virtual and real interaction, the experimenter can complete various experimental projects as if in a real environment. There is no need to worry about the damage caused by experimental operation errors or miss some classic experiments due to experimental conditions. The experimental results obtained are equivalent to or even better than those obtained in the real environment. Virtual experiments are based on a virtual experimental environment (platform simulation), focusing on the interaction of experimental operations and the simulation of experimental results. Experiments in biology, physics, chemistry and other courses can be carried out in the virtual laboratory. The interactive operation of the virtual simulation laboratory helps to cultivate students' practical ability. At the same time, the virtual experimental equipment also saves resource consumption and avoids experimental risks although its motivating properties, learning science in VR may make learners cognitive overload and distract, resulting in poorer learning outcomes.

3.4. Virtual Teacher

In recent years, based on the development of artificial intelligence technology, some entrepreneurs began to provide students with an online "virtual tutor" using artificial intelligence to help children learn (Goel, & Polepeddi, 2016). At Georgia Institute of Technology, students were fascinated by a teacher assistant named Jill Watson, who quickly and accurately answered

the student requests. However, the students did not know that Ms. Watson's true identity was actually a computer with an IBM-artificial intelligence system. There is also a company in London known as "Whizz Education" (Whizz Education, 2014), that is popular with its flagship product, "Maths Whizz," a software for online tutoring. The company has designed after-school study course that is consistent with the school schedule. Students can ask questions at any time during the learning process. The virtual teacher will answer the questions step by step for students and adjust the answer according to the feedback of the students until the student masters the knowledge learned. At the same time, the system also provides real-time reporting for parents, so that they can keep track of their child's learning progress and understand better whether they can keep up with the progress of the school or will have difficulties during the learning process and etcetera. The system allows parents to encourage and even reward their children through online interaction, in which parental supervision of children is also taken into account in the program.

3.5. Personalized Learning

Personalized learning refers to a variety of educational programs in which learning speed and teaching methods can be optimized based on each learner's needs (Bailey, 2019). The experience is tailored to learning preferences and the specific interests of different learners. This artificial intelligence educational program can adapt to the individual's learning rhythm and continue to provide more complex tasks to accelerate his/her learning process. Therefore, students who are fast or slow can continue to learn at their own pace. Holotescu designed and developed the MOOC (Massive Open Online Course) Buddy teaching robot to provide learners with targeted, personalized learning resources (Holotescu & Grosseck, 2018). Bayne has also developed intelligent teaching assistant Botty who can help teachers in the teaching process and make classroom teaching activities more efficient (Bozkurt, Kilgore & Crosslin, 2018). These educational programs would assist in many ways such as the automatic correction of work, online question answering and intelligent evaluation (Li, 2016).

3.6. Adaptive Learning

In adaptive learning, artificial intelligence is gradually used to collect and analyze student learning data and outline the learning styles and characteristics of each student, and then automatically adjust the teaching content, mode and rhythm, to best suit their needs (Wu, 2019). With the passage of time, the accumulation of data gradually increases, the more "smart" artificial intelligence will be, and the more accurate it will be in adapting to students' learning. In this way, a virtuous circle will be formed, so that students' learning efficiency will be higher and higher, the effect will be better and better, and their confidence will also be enhanced. Since its inception in 2011, a company known as "Smart Sparrow" in the United States and Australia has been working to develop adaptive teaching tools for schools and teachers (Farmer, Catalano & Halpern, 2019). Their products are the platform that integrate curriculum design, online learning, real-time feedback, adaptive learning, big data analysis, online collaborative learning, and intelligent coaching. Teachers can use the tools and content library on the online platform to design courses, and each part of the teaching process can add elements of interaction with students, so that students can master the knowledge through completing some "tasks" in the course. Through these interactions, the system can collect student learning data at any time, track the progress of students, and discover the bottlenecks and difficulties of student learning, thus giving real-time feedback and reinforcement. For younger children, some companies have added gamification to adaptive learning systems to make boring learning becomes more fun. The American company "DreamBox Learning" cuts in from the gamification of the elementary school mathematics curriculum and designs a platform for learning mathematics in games (Jani, Muszali, Nathan & Abdullah, 2018). This platform is based on the performance of students in the

game and the platform of interaction and practice, gradually to promoting student mathematics learning. It adjusts the content and exercises according to the progress of the students, so that students can learn all the mathematics courses required by their grades without realizing it.

3.7. Intelligent Campus

With the help of leading artificial intelligence technology, intelligent campus aimed to improve teaching quality as well as campus management and services, to provide a more systematic and secure environment for students (Yan, 2018). At Deakin University in Victoria, Australia, the development of smart campus is in full swing. As a teacher's aide, the intelligence behind it comes from IBM's Watson supercomputer system. Once the project is completed, the Smart Campus will be able to answer all questions related to the student's campus life such as how to find the next lecture hall, how to apply for the next semester course, how to get homework, where to find a parking lot or how to contact a professor are all that artificial intelligence campus robots will be able to solve.

3.8. Distance Learning

In 2014, Kose published the book title "Application of Artificial Intelligence in Distance Education", and believed that the application of artificial intelligence in distance education aims to study the use of computers to make up the gap between students and educators (Kose, 2014). In distance education, artificial intelligence technology should be used to support distance education, or different intelligent systems can be used to improve distance education (Kose, 2014).

4. IMPACT OF AI IN EDUCATION

The continuous improvement of AI technology has been widely used in all walks of life, and the education field is no exception. AI simulates human listening (machine translation, speech recognition) (Delić et al., 2019), speaking (speech synthesis, human-computer dialogue) (Chiba, Nose, Kase, Yamanaka, & Ito, 2019), watching (computer vision, image recognition, text recognition) (Paglen, 2019), thinking (Theorem Proving) (Sarma & Hay, 2017), learning (machine learning, intelligent adaptive learning) (Colchester et al., 2017) and action (robot) (Khandelwal et al., 2017). In particular, AI technologies such as computer vision, natural language processing, and intelligent adaptive learning have changed traditional education and teaching (Yufei, Saleh, Jiahui, & Abdullah, 2020), and have provided universities and teachers with new ideas for teaching reform. One of the importance of AI in education is it plays a role in promoting personalized teaching and learning. AI has changed the way teachers teach and the way students learn. It can form a personalized learning plan according to the needs and learning situation of students (Dishon, 2017), provide immersive learning experience (Ip et al., 2019) and intelligent learning tracking to help students improve their learning ability and efficiency. AI can deeply evaluate students' daily and test performance based on big data and machine learning, and provide personalized teaching guidance for students' difficult knowledge and difficulties(Bingham, Pane, Steiner, & Hamilton, 2018), shortening students' learning time (Quer, Muse, Nikzad, Topol, & Steinhubl, 2017) and improving learning efficiency (Kong et al., 2019). Adaptive learning technology can help implement one-to-one personalized teaching between machines and students. Intelligent adaptive learning technology is an AI education technology that simulates the process of one-to-one teaching by teachers to students and gives the learning system personalized teaching capabilities (Kakish & Pollacia, 2018). The United States' adaptive education started early, in the 1990s. It has excellent adaptive education companies such as Knewton (Conklin, 2016), Cognitive Tutor (Elazhary & Khodeir, 2017), etc., in which the

teaching content focuses on higher education. Compared to the United States, China's adaptive education development started late, and the technology is not as mature as the United States. It has only developed rapidly in the last ten years. The education content of companies such as New Oriental and Yixue Education-Squirrel AI (Knox, 2020) that do better in intelligent adaptive education focuses on K12 Tutoring and English tutoring.

5. CHALLENGES OF AI IN EDUCATION

While AI brings a series of education benefits, it will also face some unprecedented challenges. Understanding the problems that may be encountered when AI is introduced into education will help people better prepare and improve the future application of AI in education. These challenges mainly lie in the following aspects:

5.1. Fairness in the Application of AI in Education

It is necessary to ensure fairness when applying AI in education. With the development of AI, developing countries face the risk of exacerbating the divisions in education by new technologies. Just as the digital divide has separated those who can access to the Internet from those who cannot, the ever-widening algorithmic divide now threatens to deprive many educational opportunities provided by AI. Because most AI algorithms come from developed countries, the algorithms cannot fully consider the conditions of developing countries and cannot be directly applied (Yu, 2020). The education sector must overcome significant obstacles such as lacking of basic technology and infrastructure to create basic conditions for AI to improve learning.

5.2. Ethical and Safety Issues

We need to pay attention to the ethical and safety issues arising from collecting, using, and disseminating data. AI has raised many ethical issues in terms of providing personalized advice to students, collecting personal data, data privacy, and the ownership of responsibilities and data feed algorithms (Bodó et al., 2017; Southgate, 2020). Strengthening the supervision of AI technology and its products requires the public to discuss the ethics, responsibility and safety involved.

5.3. Teachers and AI-Assisted Teaching

It helps teachers prepare for AI-assisted teaching. Teachers must master new digital teaching skills in order to use AI to promote teaching reform appropriately. In addition, the developers of AI teaching products must understand the way teachers work and create a teaching product usage plan that is convenient for teachers to use.

5.4. Students' Autonomous Learning Ability

The changes in learning styles have higher requirements for students' autonomous learning ability. Learning in the era of AI will be student-centered, and students are in the dominant position in learning activities (Chang & Lu, 2019; Fu, 2020). Students can generate personalized learning plans based on the intelligent teaching system, independently select learning content, arrange learning progress, and carry out group cooperative learning (Fang et al., 2019; Walkington & Bernacki, 2020; Yilmaz, 2018). Individualized learning methods have higher requirements for students' self-regulation and self-management level (Bergamin & Hirt, 2018;

Tseng, Yi, & Yeh, 2019), so teachers should also pay attention to the cultivation of students' independent learning ability in the teaching process.

5.5. Student-Student Communication

More attention needs to be paid to student-student communication. If more and more students use AI platforms for learning, and the object of their communication is machines, the student's social communication skills will become a problem. Students should promote mutual learning. To solve this problem, AI education projects can set up a distance education model that emphasizes socialization. Students can study online and interact with classmates in different camps and social activities.

6. CONCLUSION

The objective or the purpose of this study was to assess the impact of AI on education. A qualitative research study, leveraging literature review as a research design and method was used. Journal articles, professional publications, and professional conference reports were identified and used in an analysis that facilitated the realization of the study purpose. The development and use of computers and computer related technologies have led to the development and use of AI in different sectors. Particularly, the development of the personal computers and later developments that have increasing the processing and computing capabilities have encouraged the development and use of AI, which has been shown to have a major impact on the sectors it permeates.

AI has been extensively adopted and used in the education sector, particularly, in education institutions. The analysis focused on evaluating the impact of AI on administrative, instruction, and learning aspect of education. AI in education initially took the form of computers and computer-related systems, and later, web-based and online education platform. Embedded systems have made it possible to use robots and chatbots to perform teacher or instructor-like functions. The use of these platforms and tools have enabled or improved teacher effectiveness and efficiency, resulting in improved instructional quality.

Overall, AI has had a major impact on education, particularly on administration, instruction, and learning areas. Artificial intelligence technology has been used in many different aspects in education, assisting the teaching and learning processes and managing smart campus life. With the development of AI technology, AI will be more and more used in the education field in the future, improving teachers' teaching quality and students' learning methods, and making learning more diversified and personalized.

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