A Systematic Mapping Study for the Role of Artificial Intelligence in Online Education

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Abstract
This study aims to investigate the role of artificial intelligence applications (AIA) in education. AI-driven solutions address the growing challenges in modern education, enhancing accessibility and learning outcomes. Key AI applications, including social robots (SR), smart learning (SL), and intelligent tutoring systems (ITS), play a transformative role in contemporary education. The review highlights the necessity for educational institutions to integrate AI technologies to align with evolving pedagogical demands. Furthermore, a systematic statistical evaluation is required to validate the findings and enhance their generalizability for future research.

Keyword: Artificial Intelligence, Artificial Intelligence in education (AIED), Online Education, Virtual Reality, distance learning, online educational methods

Introduction

In contemporary education, eLearning has emerged as a preferred choice for students and organizations due to its flexibility and accessibility. Modern open education models have significantly expanded learning opportunities, making educational resources available to a wider audience. These advancements have not only enhanced user trust but also facilitated the dissemination of open educational resources (OER), promoting academic transparency. As a result, there is a growing inclination toward the integration of artificial intelligence (AI) in education, with schools, universities, and business organizations increasingly recognizing its potential benefits in enhancing learning outcomes and institutional efficiency.

Education is a fundamental pillar of society, exerting a profound influence on all other sectors. Its accessibility and effectiveness are crucial for societal development, transcending various challenges. The disruptions faced by the education sector during the COVID-19 pandemic underscored its vulnerability and highlighted the need for innovative solutions, drawing significant attention from researchers. However, challenges in education extend beyond global crises and include persistent issues such as accessibility, geographical barriers, and financial constraints. While multiple approaches exist to address these challenges, this study focuses on technological advancements, particularly the role of artificial intelligence (AI), as a transformative solution in modern education.

“We live in a technology-intensive digital knowledge age, and artificial intelligence technologies (i.e., machine learning, deep learning) have penetrated every dimension of our lives, including education. Accordingly, artificial intelligence can be used to overcome many challenges faced in online distance education and can be further helpful in optimizing teaching and learning processes” [1].

Literature Review

Artificial intelligence (AI) refers to the intelligence exhibited by machines, in contrast to the consciousness and emotions inherent in human or animal intelligence. While human and animal intelligence involves awareness and emotional depth, AI lacks these attributes. The term AI was first used by John MsCarthy in 1955 and he defined it as "making a machine behave in ways that would be called intelligent if a human were so behaving" [2]. "In 1950, Alan Turing popularized that computing machines may be thinking like humans someday. He believed that in the future automated machines would make such calculations that humans would not rationally do" [3].

Artificial intelligence (AI) is often associated with supercomputers possessing advanced processing capabilities, adaptive behavior, and human-like cognitive functions. These systems integrate sensors and other technologies to enhance their interaction with human users. Popular media representations frequently depict AI in applications such as smart buildings, where it autonomously regulates air quality, temperature, and ambient settings based on occupant preferences. However, in the education sector, AI extends beyond this conventional perception of supercomputing. Its applications now encompass embedded computer systems designed to enhance learning environments, optimize instructional methodologies, and provide intelligent, adaptive educational solutions.

"AIED has Impacted both students and teachers. AIED enables personalized teaching by providing students with a better learning experience. For example, intelligent robots can always answer students' questions. Pattern recognition technology can reduce online learning by identifying student's gestures. AI technology can replace teachers to reduce the burden of teachers, but it also places higher expectations on teachers. If we take special education as an example, education for exceptional children requires constant repetition, and intelligent robots can help teachers solve repetitive problems. Intelligent robots have certain limitations. Robots cannot provide outstanding guidance to students like a 'coach.' Therefore, future expectations of teachers should also be improved" [4].

"AIED refers to using AI application programs or technologies in educational settings to facilitate decision-making, teaching, or learning. AI could play various roles in educational settings. The advancement of emerging computer technologies such as robot control, sensing devices, quantum computing, wearable devices, and the popularity of 5G wireless communication technologies and mobile has provided new opportunities and appearances for applying AI to learning and teaching design" [5].

"It is clear that AI is a fast-growing field encompassing the waste boundaries of multidisciplinesubjects from mathematics to engineering and from computer science to philosophyand linguistics. Due to its interdisciplinary nature, little agreement has been observedamong the AI experts on its common definition and understanding" [6]. As the researchexpands, it will have several applications in various areas. It contributes to the processof effective decision making, in games, etc., and further extends its applications into thefield of education and learning . "Keeping in mind the tools and services associated with AI,its presence in higher education has been noted. Interestingly many educationists are stillunaware of its importance, scope, and what it consists of" [7]. Considering the above issuearising from the unawareness of teachers in the use of AI in education, this research aimsto further explore the AI applications in education, their scope in education, and learning .

Artificial Intelligence in Education

This study examines the convergence of artificial intelligence (AI) with education, focusing on its impact across key domains. Specifically, the research explores the role of AI in educational administration and management, instructional methodologies, and learning processes. By analyzing these areas, the study aims to provide insights into how AI-driven technologies enhance efficiency, optimize teaching strategies, and improve student learning outcomes within the education sector.

- **Nature Of Artificial Intelligence**

  Artificial intelligence (AI) has traditionally been closely associated with computers. However, a review of literature, particularly within the education sector, indicates a shift beyond conventional computing systems. While computers have historically provided the foundation for AI development, there is a growing transition from viewing AI solely as hardware and software. Advances in embedded computing, sensor technologies, and other emerging innovations have enabled AI integration into a broader range of applications, including intelligent machines, smart buildings, and educational robots. This evolution highlights AI's expanding role in enhancing educational environments and learning experiences.

- **Technical Aspects Of AI In Education**

  AI-assisted education includes intelligent learning systems, advanced virtual learning environments, and data-driven analysis and prediction.As learning demands evolve, AI-enabled education is becoming increasingly vital in enhancing instructional effectiveness. Intelligent education systems offer personalized instruction and real-time feedback for both educators and learners, optimizing the overall learning experience. These systems leverage advanced computing technologies, particularly machine learning, which is closely related to statistical models and reasoning learning theories, to improve educational efficiency and value.

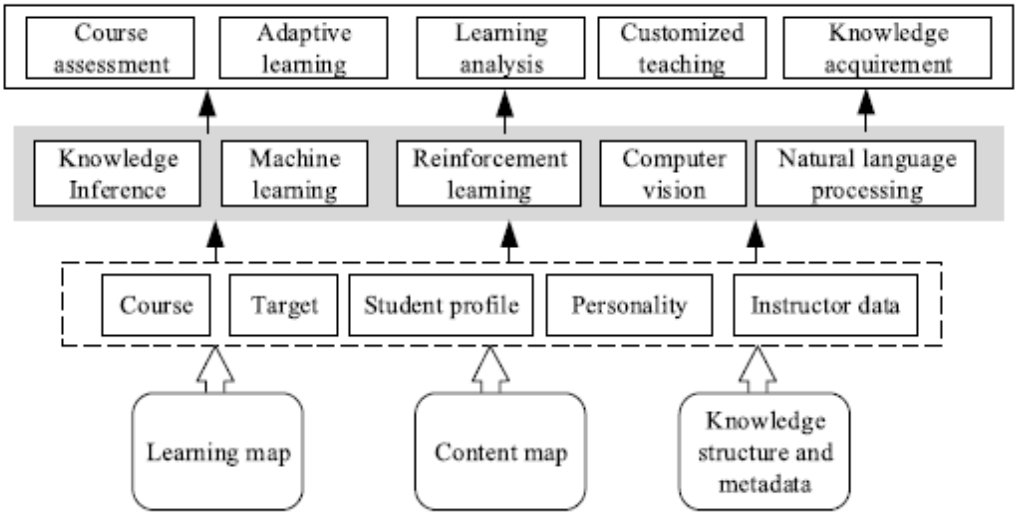

Fig.1: Technological Structure of AI in Education

AI-powered education systems integrate various techniques for learning analysis, recommendation, knowledge acquisition, and comprehension. These methods are primarily based on machine learning, data mining, and data modeling. An AI-driven education system classically comprises teaching content, data, and intelligent algorithms, which can be categorized into two key components: the system model (including learner, teaching, and knowledge models) and intelligent technologies. As illustrated in Fig. 1, system models play a critical role in constructing data maps, which launch structures and association rules for educational data. These models serve as the core of AI education systems, while intelligent technologies provide the computational power necessary for enhancing learning outcomes.

The Impact of Artificial Intelligence in Education and Beyond

- **Access to Information**: In the past, accessing information required extensive effort, such as visiting libraries and searching through numerous books. With advancements in artificial intelligence and technology, obtaining desired information has become significantly faster and more efficient. Virtual

assistants on mobile devices now enable users to access information with just a few voice commands, streamlining the process of learning and information retrieval.

- **Distance Learning**: Technological advancements, particularly in computer systems, have made distance education (online learning) a viable option. During the challenging COVID-19 pandemic, AI-driven systems played a crucial role in maintaining the continuity of education and mitigating the spread of the virus through virtual learning platforms.
- **Personalization in Education**: Traditional classrooms often struggle to meet the individual needs of every student. Artificial intelligence addresses this challenge by offering personalized learning experiences. AI systems enable students to revisit lessons or parts of lessons they may not have fully understood, thereby facilitating a more tailored and effective educational experience.
- **Global Knowledge**: AI technologies have bridged language barriers in education, allowing learners to access content in foreign languages and receive real-time translations. This capability not only facilitates language learning but also helps translate and adapt educational content from various languages into a learner's native language, making global knowledge more accessible.
- **Student Attendance Tracking**: AI-powered sensors in schools help track student attendance automatically, eliminating the need for teachers to manually take attendance. These intelligent systems streamline the administrative process, making it easier to monitor absenteeism and ensure accurate records.
- **Digitalization and Environmental Protection**: The shift from paper-based to digital educational resources has contributed significantly to environmental sustainability by reducing the need for paper and conserving natural resources. Additionally, with the rise of online education, the reduction in transportation needs has decreased traffic congestion and reduced harmful emissions from student commutes, further benefiting the environment.
- **Removing Barriers for Disabled Students**: AI has made education more accessible for students with disabilities. By integrating systems that convert text to speech or audio to text, AI helps visually and hearing-impaired individuals engage with learning materials. Furthermore, students with mobility issues can attend classes virtually, eliminating physical barriers to participation and enabling greater independence and inclusion.
- **Error Reduction**: AI minimizes human error, particularly in grading and decision-making processes. Unlike humans, AI lacks emotional biases and can provide more objective, accurate, and fair assessments. For example, AI can assess assignments or exams more consistently than a human teacher, ensuring a more reliable evaluation system.
- **Taking on Challenging Explorations**: AI-driven robots are utilized in dangerous environments where human presence is impossible or impractical. In fields such as mining, space exploration, and underwater research, AI robots can perform tasks such as searching for energy resources or exploring oxygen-free environments, making discoveries that would otherwise be unattainable.
- **Medical Applications**: In healthcare, AI is revolutionizing the way doctors diagnose and treat patients. AI applications analyze medical records, assist in decision-making, and help healthcare professionals make faster, more accurate diagnoses. Additionally, AI technologies are being used to enhance medical education, helping students better understand complex medical concepts and conditions.
- **Uninterrupted Operation for Long Periods**: AI-powered machines do not require breaks or rest, enabling them to operate continuously for long hours without fatigue or distraction. For instance, AI-driven teaching robots can offer instruction at any time, without the limitations that human instructors face in terms of working hours.

- **Daily Applications**: AI is embedded in everyday technologies that we use without much thought. From correcting spelling errors in text messages to facial recognition software that tags individuals in photos, AI applications are part of our daily routines. Navigation systems powered by AI also provide real-time directions, improving travel efficiency. Overall, AI is seamlessly integrated into numerous aspects of daily life, showcasing its broad utility across different domains.

Challenges and Concerns Associated with Artificial Intelligence in Education

- **Technology Addiction**: The increasing interaction of students with social media and digital platforms has led to a reduction in face-to-face social interactions. Excessive time spent on technology—particularly in virtual environments and gaming—has resulted in students neglecting their educational responsibilities and motivation. This behavior, often causing a shift of nearly 90% of their free time toward digital activities, detracts from time that should be devoted to academic pursuits. Parents commonly express concern about this trend, as it negatively impacts students' academic focus.
- **Negative Impact on Social Life**: Before the widespread adoption of artificial intelligence, students frequently engaged in group work and social collaboration. However, the development of technology has shifted these interactions to more solitary activities. Tools like tablets and computers, which students use for research and learning, have replaced the communal and interactive environment of traditional libraries. As a result, students' ability to collaborate in-person has been diminished, leading to the emergence of more isolated, asocial behaviors.
- **Negative Impact on Health**: The increased reliance on AI-driven technology also contributes to rising levels of stress and competition among students. This heightened pressure can adversely affect their mental health and overall psychological well-being. Furthermore, prolonged use of technological devices poses physical health risks, including eye strain, nerve compression, and musculoskeletal issues such as neck, back, and wrist pain. The radiation emitted by these devices also exacerbates health concerns for individuals spending excessive time with technology.
- **Risk of Unemployment**: The growing integration of AI and automation into the workforce has raised concerns about job displacement. Machines are increasingly replacing human workers in various sectors, including education, where robotic teachers could potentially replace traditional human educators. While robots offer accuracy and reliability, the risk of reducing human creativity and innovation is high. As AI systems take over routine tasks, they may foster dependency, reduce motivation, and lead to a decline in workers' creative capabilities.
- **Lack of Creativity**: Artificial intelligence lacks the imaginative and creative abilities inherent in human beings. While AI systems can generate designs or mimic certain behaviors, they are incapable of producing the original, emotionally-driven innovations that humans can. Human intelligence is dynamic, shaped by emotions, creativity, and unique cognitive processes, while AI remains confined to pre-programmed tasks, devoid of emotional intelligence and adaptive thinking.
- **Income Distribution Imbalance**: Access to advanced technology is often determined by financial means, leading to significant disparities in educational opportunities. Students from higher-income backgrounds can afford cutting-edge technologies, whereas those from low-income households may lack access to essential tools such as computers and reliable internet connections. This inequality was especially evident during the COVID-19 pandemic, when rural students were unable to participate in online learning due to a lack of technological resources. As a result, students in economically disadvantaged regions were deprived of their right to education, while those in wealthier areas were able to continue their studies, exacerbating the educational divide.

- **High Cost of Development and Maintenance**: Developing and maintaining AI systems is an expensive endeavor due to their complexity. These machines require constant innovation, software updates, and troubleshooting, all of which incur significant costs. Additionally, the potential for system crashes or failures necessitates frequent maintenance, leading to both time and financial losses. This challenge is particularly relevant in the education sector, where the integration of AI technology requires substantial financial investment for upkeep and continuous improvement.
- **Ethical Concerns**: AI systems can make decisions based solely on their programming, but they lack the human capacity for ethical reasoning or empathy. As a result, AI may make choices that are technically correct but ethically questionable, as it does not possess the moral understanding that guides human decisions. In extreme cases, AI may fail to recognize the nuances of complex situations, leading to unethical outcomes.
- **Lack of Human Experience**: Unlike humans, AI systems do not learn from personal experiences or emotional growth. While they can process large datasets and generate insights, they cannot replicate the wisdom or judgment that comes from lived experiences. Machines do not experience anxiety, uncertainty, or the sense of belonging, which are integral to human decision-making. Their reliance on data and algorithms limits their capacity to act with the empathy and understanding that humans bring to problem-solving.

Conclusion

This study explored the role of artificial intelligence in online distance education using a systematic review approach. The analysis revealed a growing research interest and widespread adoption of AI technologies in education, underscoring the need for further examination from multiple perspectives. The findings highlight a significant reliance on AI-driven systems, suggesting that algorithmic advancements will continue to shape the future of education. Based on the review, three key research themes were identified: (1) educational data mining, learning analytics, and AI for adaptive and modified learning; (2) algorithmic online educational environments, ethical considerations, and human agency; and (3) AI-driven online learning through detection, identification, recognition, and predictive analytics.

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