

Research Analysis on the Application of Artificial Intelligence Technology in Education

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Abstract. The rapid development of artificial intelligence is profoundly changing the global education landscape, providing unprecedented opportunities to meet the long-term challenges of teaching and learning. This article reviews the integration of artificial intelligence in education, focusing on core technologies such as machine learning, natural language processing and intelligent tutoring system. It shows specific case studies and how artificial intelligence can enhance personalized learning, automate management tasks and support data-driven teaching decision-making. It systematically examines key challenges, including data privacy, algorithm bias, teacher role shift and digital divide, and emphasizes the need for proactive ethical and fair solutions. Looking to the future, the future of artificial intelligence in the field of education is not to replace human educators, but to promote the cooperation between people and artificial intelligence. Emerging trends point to explainable artificial intelligence systems, pay more attention to social emotional learning, and the development of a comprehensive lifelong learning ecosystem. The review emphasizes the importance of a sound, ethically based and equity-centered artificial intelligence integration approach in teaching, and believes that successful implementation requires the coordinated efforts of decision-makers, educators, technical experts and researchers.

1 Introduction

The rapid development of artificial intelligence is reshaping the global industry and society, and education is no exception. Artificial intelligence integration into education, commonly known as AIED, has changed from a future concept to today's reality driven by big data, increased computing power and complex machine learning algorithms. This transformation not only represents the upgrading of technology, but also the fundamental change of the teaching paradigm. As Yang and others pointed out, the application of artificial intelligence in education is developing rapidly, shifting from the initial exploration to a mature and diversified implementation model. The growing expectations of society for the cultivation of higher standards have exposed the limitations of the traditional "one-size-fits-all" model, and there is an urgent need for a more personalized, efficient and fairer learning path.

Studying the role of artificial intelligence in education has multiple significance. First of all, artificial intelligence provides unprecedented potential for personalized learning. By analyzing the learning style, rhythm, knowledge gap and performance data of individual students, the artificial intelligence system can customize the content, provide customized suggestions, and provide real-time targeted feedback, so as to optimize educational results. Secondly, artificial intelligence can automate daily management and teaching tasks, such as scoring, scheduling and

answering common student questions. This allows educators to focus on more complex and people-oriented activities, such as guiding, cultivating critical thinking and providing emotional support, so as to improve the overall teaching effect. Third, artificial intelligence-driven tools can make education more accessible and inclusive. For example, speech-to-text, translation and personalized interfaces provide support for students with disabilities or non-native learning. Finally, at the system level, artificial intelligence can analyze a large amount of educational data, provide information for curriculum development, institutional decision-making and policy formulation, and promote the large-scale improvement of quality and fairness. When people navigate the complexity of the 21st century, knowing how to take advantage of the potential of artificial intelligence while reducing its risks is the most important thing for educators, decision-makers, technicians and learners.

The academic community responded positively to AIED. Recent studies have provided a solid foundation for understanding the current situation. Yang and others gave an extensive overview of the development and application of artificial intelligence in education, and discussed various technical forms and their integration into teaching and management processes. Luo has deeply studied specific application scenarios and emphasized how artificial intelligence empowers teaching and learning activities. From a forward-looking perspective, Hu et al. studied the integration of artificial intelligence in higher education, analyzed the current

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trend, and put forward a development path. Gu focuses on the transformation potential of artificial intelligence in personalized learning, believing that artificial intelligence has transformed from unified teaching to a model that truly meets the needs of individual students. In addition to these thematic studies, Garzón, Patiño and Marulanda systematically draw the trends, benefits and challenges of the whole field, confirming the global research interest in intelligent tutoring systems, adaptive learning platforms and predictive analysis, while always pointing out moral and practical challenges. Overall, these studies show a clear trajectory. AIED research is going from a descriptive description of potential to a more critical analysis of implementation, effectiveness and ethical impact. They confirmed the great prospects of artificial intelligence and established the need to carefully consider its challenges.

2 Core technologies in AI-enhanced education

2.1 Machine learning and predictive analytics

Machine learning (ML), especially supervised and unsupervised learning, enables the system to identify patterns and regularities from educational data such as student performance, attendance records and online behavior logs. By learning from these data, machine learning can simulate and optimize educational decision-making and provide a data-driven basis for personalized teaching.

Luo discussed how machine learning technology can support learning path suggestions and predict the next best content based on students' historical performance [1]. Zhang and Xu emphasized the use of machine learning in the early warning system, which can identify students at risk of dropout or failure and allow timely intervention [2]. Garzón, Patiño, Marulanda and Liu further confirmed the role of machine learning in student performance prediction, providing teachers with evidence-based insights for targeted coaching [3,4].

The main advantages of machine learning include scalable and precise personalized support, helping educators make data-driven decisions beyond intuition, and discovering complex correlations that humans may miss. However, there are restrictions. The accuracy of the model largely depends on the quality and quantity of the training data ("garbage in, garbage out"). Algorithmic bias may exacerbate educational inequality. In addition, predictions usually reflect correlation rather than causality, which may mislead intervention. The "black box" nature of many machine learning models also undermines the trust between teachers and students [3,4].

2.2 Natural language processing and conversational agents

Natural language processing (NLP) enables computers to understand, interpret and generate human language. Its core educational value is to promote natural human-computer interaction, break the limitations of the

traditional graphical user interface, and achieve a more intuitive learning experience.

Hu et al., as well as Idhalama, Aluede and Batagarawa, described how NLP supports an intelligent tutoring system that participates in Socrates' dialogue, an automatic paper scoring system that provides instant feedback on grammar, style and structure, and answers to common course or administrative questions 24/7. Online chatbot [5,6]. Zhang, Bai, Fan and Ali further pointed out the role of NLP in providing language learning assistants for dialogue practice and pronunciation correction [7,8]. Wen Hua Zhang also emphasized the extensive deployment of NLP-based tools in the educational environment to automatically answer questions [9].

The advantages of NLP include providing instant and personalized feedback, greatly expanding the time and space of teacher-student interaction, reducing the burden of repeated answers for educators, and creating an immersive and low-stress environment for language practice. Nevertheless, NLP is still struggling with complex, open-ended questions or language with a strong emotional tone. The feedback generated may still be superficial and lacks profound human empathy and creative inspiration. In addition, over-reliance on NLP tools causes academic integrity problems, such as students using artificial intelligence to complete writing homework without real effort [8,7].

2.3 Intelligent tutoring systems and adaptive learning platforms

The intelligent tutoring system (ITS) and the adaptive learning platform integrate the technologies discussed in the previous sections. They usually consist of domain knowledge models, student models, teaching models and interactive interfaces, which aim to simulate the function of human one-on-one tutors by dynamically adjusting content, rhythm and teaching strategies.

Yang et al., Chen and Ren described practical examples, such as Khan Academy's personalized exercises, Duolingo's language learning path, and intelligent platforms used in hybrid higher education, which push different classroom activity materials according to students' preview performance. [10,11]. Wang, Zhang, Jin and Cabanillas García further confirmed that ITS effectively realized the ideal of teaching according to personal ability, so that each student could learn at his own pace [12,13]. Gu believes that ITS is a key driving factor for the shift from unified teaching to truly personalized learning [14].

The most important advantage of ITS is that it can realize truly personalized teaching. Real-time data and feedback improve learning efficiency and knowledge mastery. These systems also provide strong technical support for flipped classrooms and blended learning. However, the development and maintenance costs are still very high. Teaching strategies and knowledge expressions are relatively fixed and may not be able to adapt to all learning styles. Over-reliance may lead to the isolation of students and weaken the real social interaction with peers and teachers. In addition, the role

of ITS in cultivating high-level abilities such as metacognition and creativity is limited [13,14].

3 Practical applications and empirical results

3.1 Case study one: using the adaptive learning platform to carry out hybrid teaching reform of college mathematics

Due to the huge difference in students' previous knowledge, the advanced mathematics courses of universities face major challenges. The traditional form of large class lectures is difficult to meet personal learning needs, resulting in uneven performance and low participation.

In order to solve this problem, the institution has introduced an adaptive learning platform integrated with machine learning algorithms (corresponding to Sections 2.1 and 2.3). Before each class, students use the platform to preview. The system diagnoses their knowledge gap based on their answers to diagnostic questions, and then pushes personalized micro-lectures and exercises. In class, the instructor reviewed the report on the overall classroom performance generated by the platform, and conducted targeted lectures and group discussions accordingly.

Chen and Ren evaluated this hybrid teaching reform [11]. The results show that the final average score of students has increased significantly, and the rate of course failure has decreased significantly. The student satisfaction survey shows that learning autonomy and interest are enhanced. The lecturer reported that the platform helped them identify and focus on key teaching points more accurately, making their teaching more data-driven and efficient.

This case shows how artificial intelligence enhances hybrid teaching by realizing data-driven precise teaching and personalized learning. The adaptive platform transforms one-size-fits-all lectures into a flexible and responsive learning environment.

3.2 Case study two: application of an NLP-based automated paper scoring system in middle school writing teaching

Middle school Chinese teachers bear a heavy burden when grading students' papers. The long feedback cycle limits students' opportunities for writing guidance and revision in time, which hinders the development of writing.

An automatic composition scoring system based on natural language processing is adopted (corresponding to Section 2.2). Students submit papers online, and the system provides multi-dimensional instant scores and revision suggestions, including vocabulary, grammar, structure and logical coherence. Then, teachers conduct higher-level evaluation and face-to-face tutoring according to the output of the system.

Luo, Hu and Ali discussed similar applications and their results [1,5,8]. Students increased the frequency and number of revisions, thus improving their writing

skills. Teachers spend less time on mechanical scoring, allowing them to devote more energy to in-depth discussions with students. In addition, the students reported that they were less anxious about writing and more willing to revise their work.

This case illustrates the role of artificial intelligence as a "teaching assistant". It provides instant high-frequency formative evaluation, releases teachers' ability, and improves the overall teaching efficiency.

3.3 Case study three: intelligent predictive systems for students' success

Universities are facing the ongoing problem of student dropout rate. Early identification of high-risk students and targeted support are crucial, but often lacking, resulting in missed opportunities for intervention.

A student success prediction system based on machine learning has been deployed (corresponding to Section 2.1). The system integrates multi-dimensional data, including students' academic records, attendance rate, library borrowing history, campus card transactions and online learning platform behavior. A predictive model was built to assess the academic risk level of each student. Then, the visual report is pushed to the academic advisors and instructors.

Zhang, Xu and Liu put forward evidence of such a system [2,4]. The accuracy of identifying high-risk students has been significantly improved. Intervention measures - such as consultation meetings and academic guidance - have become more targeted and timely, effectively reducing the dropout rate. The system has transformed from reactive response to active intervention.

This case shows the application of artificial intelligence in educational management. Predictive analysis transforms from "reactive response" to "active intervention", reflecting the improvement of educational governance.

4 Discussion: challenges and future prospects

4.1 Major challenges

Several key challenges must be solved. First of all, data privacy and security are the most important, because education data contains sensitive personal information. Idhalama, Aluede, Batagarawa and Zhang, Bai and Fan expressed concern about data collection boundaries, secure storage and regulatory compliance [6-8]. Secondly, algorithmic bias and fairness pose a risk, and the bias of training data related to race, gender or socioeconomic status may be amplified, leading to unfair treatment of certain groups of students [6,7,15]. Third, regarding the role of teachers, artificial intelligence is not a substitute, but a tool that reshapes educators into learning designers and emotional supporters, which requires effective people to cooperate with artificial intelligence [5,3,13]. Finally, the digital divide threatens educational equity, because the implementation of artificial intelligence depends on

unevenly distributed hardware, Internet access and digital literacy [7,9].

4.2 Future prospects

Looking to the future, artificial intelligence will transcend teaching aids, embed in the empowering learning ecosystem, connect formal and informal learning and support lifelong education [5,8,12]. As artificial intelligence takes over cognitive tasks, education will pay more and more attention to emotional and social skills - creativity, empathy and collaboration - social emotional learning is becoming more and more prominent [6,13]. In addition, explainable AI (XAI) will be prioritized to overcome the "black box" problem and build a reliable and transparent AIED system [4,6,7]. Although artificial intelligence (AGI) is still speculative, its potential impact invites continuous critical reflection on the long-term trajectory of artificial intelligence in education [5].

5 Conclusion

This article comprehensively reviews the integration of artificial intelligence in education, and studies core technologies, practical applications and related challenges. The analysis of machine learning, natural language processing and intelligent tutoring systems shows that each technology provides unique educational advantages, but there are also inherent limitations related to data dependence, interpretability and teaching ability. These three case studies - the adaptive learning platform of college mathematics, the NLP-based thesis scoring system for middle school writing teaching, and the predictive analysis system for students' success - show that artificial intelligence can effectively personalize learning, automate daily tasks, and realize data-driven work across different educational backgrounds. Pre. The empirical evidence of these applications shows that they improve learning outcomes, improve teacher efficiency, and support students more timely.

However, the discussion also highlights the key challenges that must be actively addressed. Data privacy and security, algorithm bias, the changing role of teachers, and the digital divide all pose major risks to the fair and ethical implementation of artificial intelligence. These problems require not only technical solutions, but also a policy framework, the professional development of educators, and continuous attention to social justice. Looking to the future, the future of artificial intelligence in the field of education does not lie in replacing human educators, but in promoting the synergy between people and artificial intelligence. Emerging trends point to explainable artificial intelligence, with more emphasis on social emotional learning and the development of lifelong learning ecosystems. Although artificial intelligence may eventually bring about changes, the top priority is to integrate artificial intelligence in a sound, morally responsible and equity-centered approach in teaching.

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