The comprehensive investigation of the role related to artificial intelligence in education

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Abstract. This systematic literature review extensively explores the prospects of Artificial Intelligence (AI) applications in the realm of learning from 2019 to 2023. It delves into key areas such as intelligent tutoring systems and online learning platforms, while meticulously examining their underlying technologies. The coverage includes methods for integrating AI into student models, as well as algorithms for enhancing adaptive learning and improving the precision of personalized learning content recommendations. The paper also discusses challenges and prospects, including the potential of AI to reshape the teaching profession and privacy concerns. The review underscores the ongoing necessity of striking a balance between human involvement and automation, emphasizing that AI serves as an auxiliary tool rather than a replacement in education. Additionally, the study investigates the integration of AI in online learning, emphasizing the need for user-friendly interfaces and robust data protection policies. Lastly, the research highlights the importance of interdisciplinary collaboration and ethical considerations, envisioning a future where AI and education seamlessly harmonize.

Keywords: artificial intelligence, education, machine learning.

1. Introduction

Education stands as an immensely momentous subject of inquiry, bearing substantial implications for both individuals and society at large. Throughout human history, education has consistently played a crucial role in advancing human civilization. It comprises early education and higher education [1] and can further be subdivided into various branches, such as preschool education, middle school education and vocational education etc. However, traditional educational models confront a host of challenges, with the most significant being the imbalance in teacher-student ratios due to a shortage of qualified educators. This leads to unequal distribution of educational resources, a monotonous educational approach, and untimely feedback on learning outcomes. These issues largely hinder students' learning efficiency and motivation.

Fortunately, the proliferation of computers and the advancement of Artificial Intelligence (AI) technology have bestowed unprecedented opportunities upon the domain of education. Although artificial intelligence has only entered the public's spotlight in recent years, AI education has been a research field since the 1980s. The research direction in AI education can be divided into two paths: one is the development of AI-based classroom tools, and the other is using artificial intelligence to gain insights, assess, and optimize learning processes [2].

The application of AI in the realm of pedagogy has a diverse history. Early efforts in this domain, pioneered by individuals such as Pressey, culminated in the development of learning machines aimed at furnishing students with instantaneous feedback to facilitate their problem-solving progress. Subsequently, the commercialization of Self-Adaptive Knowledge Interface (SAKI) sought to meet the personalized learning needs of students. With the widespread use of computers, Computer-Aided Instruction (CAI) became extensively utilized in teaching. Currently, Intelligent Tutoring Systems (ITS) have gained significant recognition [3]. Taking ITS as an example, it effectively addresses the challenge of limited teaching resources for one-on-one instruction by harnessing AI technology to simulate the outcomes of personalized tutoring, thereby ushering in adaptive learning. As a result, students are empowered to embark on self-directed learning endeavours guided by tailored instructional suggestions [4]. Furthermore, AI's applications in education extend to virtual environment learning, online learning platforms, and various other domains. Conducting a thorough review in this field is extremely important because the utilization of artificial intelligence to educational institutions spans various areas and features. Through a systematic review, a more profound apprehension of the current status, advantages, limitations, and future directions of various applications can be achieved.

This article provides a systematic review of the literature published between 2019 and 2023 regarding the applications of AI in education. It primarily examines several key application scenarios, including Intelligent Tutoring Systems (ITS) and online education platforms. Additionally, the study also focuses on the supporting technologies for these applications, such as machine learning, data mining, and model construction [5]. In this review, several discussions were conducted on the potential challenges and concerns that AI might face in the education field. These include whether AI might replace teachers or have negative impacts on the education industry, issues related to privacy protection, cost considerations, and the acceptance of AI technology. Furthermore, the review also summarizes potential future research directions, such as redefining educational theories and modifying learning and assessment methods [6]. By exploring these research directions, it is hoped that AI's development in education can be further advanced, improving the educational system, and enhancing students' learning effectiveness and experiences.

2. Method

Regarding the application of artificial intelligence in education, two of the most common examples are intelligent tutoring systems and online education platforms. This section will introduce the research outcomes and practical applications of this field.

2.1. Intelligent tutoring system

In contrast with traditional computer-assisted instruction, intelligent tutoring systems, while also being software, leverage artificial intelligence technology to provide students with one-on-one instructional guidance, achieving a teaching experience nearly indistinguishable from that of a human tutor. Typically, intelligent tutoring systems consist of four components: student models, pedagogical models, knowledge models, and user interface models [7]. The student model represents an abstract expression of the student's learning state. By analysing factors such as the student's learning behaviours and response times, it can provide a rough assessment of the student's learning condition. The pedagogical model, rooted in the principles of cognitive science and informed by pedagogical strategies, exercises a determinative influence over the instructional modality designated for students, contingent upon their individualized learning status, thus establishing a closely intertwined relationship with the student model. The knowledge model encompasses the specialized knowledge in a particular field that one aims to impart through the intelligent tutoring system, aiding the system in grasping the core concepts of that domain. The user interface model, on the other hand, is dedicated to enhancing interaction between users and the system, involving matters of how teaching content is presented and the arrangement of elements [7]. However, it is noteworthy that the composition of these components may exhibit variations across distinct ITS implementations, a dynamic that will be further elucidated in ensuing discourse [8, 9].

2.1.1. Intelligent tutoring system based on bayesian networks and fuzzy logic. Eryılmaz et al. [10] have developed an intelligent assistive system named FB-ITS aimed at promoting personalized adaptive learning for students. This system integrates two artificial intelligence methods, namely fuzzy logic and Bayesian networks.

The student model created through this combination can effectively assess students' grasp of various knowledge points and determine their readiness to proceed to the next learning topic. The implementation of this approach consists of two layers: firstly, utilizing fuzzy logic for evaluation, considering pre-test and topic test scores; secondly, employing Bayesian networks to predict students' preparedness levels for different subjects. Fuzzy logic gathers evidence to update the Bayesian networks, with these probabilities guiding system decisions, while color-coded topic links represent the predictive outcomes.

FB-ITS's knowledge model encompasses materials and test questions related to Excel courses, delivered to students in various formats including videos, images, and text. Each topic corresponds to a node in the Bayesian network. Moreover, this intelligent assistive system also employs an adaptation model that combines information from the student and knowledge models. Based on students' preferences and goals, the adaptation model tailors the learning content to the current student's needs for the user interface model.

2.1.2. An intelligent tutoring system for math education. In the pursuit of personalized mathematical knowledge acquisition among students, Lu et al. [11] have developed an intelligent tutoring system named RadarMath. Through the user interface, this system provides access to a knowledge graph and unit tests, which include both text-based math problems and formula-based math problems. The students' answers are evaluated by two types of automated scoring models. The scoring model for text-based math problems is based on deep learning, utilizing reference answers and student responses as inputs and generating scoring results as outputs. In terms of formula-based math problems, the scoring is based on the STACK model, an open-source package designed specifically for evaluating complex formulas. The outcomes of the scoring, along with the students' learning behaviors e.g. the time taken to grasp specific concepts, will be employed to assess the students' learning status and generate personalized reports. Additionally, they have employed a knowledge tracking model to update the knowledge graph using real-time learning statuses as crucial information.

2.2. Online learning platform

The advent of computational technology has engendered the feasibility of online learning. Influenced by Covid-19, online learning has garnered more attention, leading many educational institutions to replace traditional teaching entirely with online methods. However, within online educational platforms, there exists an abundance of educational resources, often leaving students struggling to locate suitable learning materials, thus impacting their learning efficiency. Artificial intelligence, as an auxiliary technology, has the potential to offer personalized learning resources to students, thereby bringing about a positive impact on online education.

2.2.1. Personalized online learning resource recommendation. In online learning platforms, common recommendation algorithms can be categorized into three main types, namely user-based recommendations, item-based recommendations, and hybrid recommendations. The recommendation algorithm studied by Wei et al. [12] falls into the hybrid recommendation category, which means it focuses not only on students' characteristics but also on features of educational resources. By combining improvements to the Linear Upper Confidence Bound algorithm (LinUCB) with insights from educational psychology, their recommendation algorithm can provide students with appropriate educational videos. While the LinUCB algorithm is commonly applied in scenarios like music recommendations and product sales, its relevance in the field of education is limited. This is primarily due to its lack of consideration for students' personalized traits. To address this shortcoming, they initially assess students' learning statuses and classify them based on evaluation results and clustering

methods, thereby deriving personalized features. They then proceed to extract features from students' learning behaviour records to characterize educational videos, including aspects like video difficulty levels. This approach facilitates in effectively tailoring personalized recommendation content, aligning it more closely with students' actual knowledge proficiency levels.

3. Application and discussion

Based on the current progress of literature, it has been found that the application of artificial intelligence in the field of education is primarily concentrated in two areas, namely intelligent tutoring systems and online educational platforms. This section will introduce the challenges faced when applying artificial intelligence in these two areas, as well as future development trends.

3.1. Intelligent tutoring system

Utilizing artificial intelligence in conjunction with specific algorithms e.g., the optimized ant colony algorithm, students can receive customized feedback when using intelligent tutoring systems, enhancing the learning experience [13]. Artificial intelligence can be also applied in intelligent support systems to achieve functions like automated grading, personalized learning guidance [11], and adaptive learning [10].

3.1.1. Challenges and future prospect. The primary challenge of applying artificial intelligence in intelligent tutoring systems lies in striking a balance between human intervention and automation [9]. In instances where the constitutive intelligent and automated constituents inherent to an intelligent tutoring system exhibit insufficiency, an inclination emerges within individuals to raise inquiries regarding the system's cognitive prowess. Conversely, if an intelligent tutoring system becomes excessively intelligent, concerns arise about its potential to replace the teaching profession. Therefore, future plans should prioritize achieving a balance between human involvement and automation. It's essential to ensure that while intelligent tutoring systems provide automated support, they also retain the role of human educators. The aim is to ensure that artificial intelligence serves as a supplementary tool for educators rather than a complete replacement.

3.2. Online learning platform

The benefits of online learning platforms are that users can utilize fragmented time for self-directed learning. However, these platforms often contain numerous learning resources, and users are prone to becoming overwhelmed in these resources, leading to a decrease in their overall learning effectiveness [14]. By integrating artificial intelligence with online learning platforms, users can conveniently and accurately retrieve the required learning content more quickly.

3.2.1. Challenges and future prospect. Online learning platforms often involve personalized learning strategies, necessitating the collection and assessment of student data. However, ensuring the privacy and security of this data is a significant challenge. To safeguard student information from infringement, educational platforms should establish strict data protection policies. Additionally, due to varying levels of familiarity and adaptability to artificial intelligence technology among students and teachers, the development of user-friendly interfaces is key to addressing this challenge. This will ensure that the technology is accessible and operable for everyone. Future research could potentially combine fields e.g., cognitive psychology, human-computer interaction, and artificial intelligence with online learning platforms, fostering the emergence of novel innovations. By integrating knowledge from these relevant fields in research, it is possible to offer a more optimized experience for online learning.

4. Conclusion

This review systematically investigates the literature related to the application of artificial intelligence in education from 2019 to 2023, elucidating the methodologies associated with these applications. The paper summarizes common scenarios of artificial intelligence application in the educational domain,

such as intelligent tutoring systems and online learning platforms. Through the exposition of these topics, it aims to provide individuals interested in this field with a foundational understanding of research trends and challenges within this domain. Despite the concerted effort to integrate a substantial volume of relevant literature, this review still encounters certain limitations in the process. These limitations might impact the credibility and comprehensiveness of the review. For instance, due to the extensive quantity of literature, there might be aspects where it is impossible to encompass all pertinent studies, resulting in gaps in information in certain areas. In the future, updating the review with new research and investigating the practical impacts of AI in education, along with addressing ethical concerns and fostering interdisciplinary collaboration, should be priorities for advancing the field.

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