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AI Applications in Education: A review

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Abstract— This paper presents a review of the applications of Artificial Intelligence (AI) in education. This review aims to explore how artificial intelligence (AI) is being used in education and how it can improve both the learning process and the results for students. Moreover, the purpose of this research is to investigate how AI bolsters contemporary pedagogical practices that captivate and inspire students. A qualitative research design using a retrogressive approach was adopted to analyze previous studies and literature. As a result, four key AI applications in education were identified: profiling and prediction, Intelligent Tutoring Systems, automation, and educational robots and chatbots. Those AI applications enrich the learning process and improve the learning results. In conclusion, this research has improved the significance that AI can have in education by offering more adaptive, responsive, and personalized experiences, as well as supporting the shift to modern teaching methods.

Keywords—AI in education, modern teaching methods, Intelligent tutoring systems, profiling and prediction, educational robots, chatbots, automation, personalized learning.

I. Introduction

Over the decades, teaching theories have evolved from traditional to modern teaching methods. In traditional teaching, teachers, as the main facilitators of the traditional learning process, determine the teaching objectives, content, methods, and assessment processes [1]. Besides, theoretical knowledge is provided to students, highlighting passive learning [1] which contrasts with contemporary teaching methods that prioritize student engagement and exploration. These methods focus on active participation, personalized instruction, and practical applications to meet students' learning needs and improve their educational experience [2]. Modern teaching methods aim to overcome the limitations of traditional approaches.

Furthermore, Integrating technology in education, especially artificial intelligence (AI) can enrich students' learning experiences and outcomes [1], through offering personalized learning, providing instant feedback, and creating more interactive and adaptive learning environments [3]. The concept of AI in education (AIED) has emerged because of this AI integration [4].

The review aims to analyze the role of AI in enhancing contemporary teaching methods and to investigate the AI technologies that contribute to improved learning processes and student outcomes. In fact, we aimed to answer the following research question: How does AI application in education help apply modern teaching methods and improve the learning experience and student outcomes?

This paper is organized as follows: The first section highlights the methodology adopted to conduct this review. Followed by the literature review section where key concepts of AI and AIED were discussed as well as relevant studies. Next, AI applications in the education section present a synthesis of our findings. The discussion section then outlines the main outcomes of the study, addresses its limitations and suggests areas for future research.

II. Methodology

A. Materials and Methods

To gain a comprehensive understanding of AI applications in education we adopted a qualitative research design using a retrogressive approach, which we systematically reviewed existing secondary data, such as previous reviews and studies conducted between 2016 and 2024.

This approach allows for in-depth analysis of established knowledge, offering insight into trends, challenges and opportunities already explored in the literature[5].

B. Search Strategy

To collect papers that directly answer our research question, we conducted a comprehensive search across multiple academic databases such as Scopus, Web of Science, and Google Scholar. These databases were chosen for their

extensive collections of scholarly articles and their accessibility for Moroccan PhD students. To refine our research and directly find relevant articles, we used specific keywords and phrases, as shown in Table I. We also filtered the selected papers based on publication date, title, keywords and abstract. If an article was relevant to our research, we added it to our collection.

After selecting relevant papers, we thoroughly analyzed their content, including the references, to ensure comprehensive coverage. Relevant references were added to our collection. Adopting snowballing approach.

Finally, the findings were synthesized by grouping similar AI applications in education under broader categories, creating a cohesive overview.

Table I. Initial search string

Topic	Search terms
Artificial intelligence	"Artificial Intelligence" OR "AI" OR "Artificial Intelligence Applications" OR "AI applications" OR "Intelligent tutoring systems" OR "AI Automation" OR "Chat bots" OR "educational robots"
AND	
Education	"education" OR "higher education" OR "learning process" OR "student outcome" OR "teacher" OR "student" OR "learn"

III. Literature Review

A. Artificial Intelligence (AI)

Due to the advancements in computing and information processing techniques, Artificial Intelligence (AI) has significantly known a rapid progression recently [3]. It is defined as the capacity of machines to perform tasks comparable to those performed by humans by learning from experiences, adapting to new information and executing tasks [6]. The term 'AI' and the concept of 'AI systems' were first coined and introduced in the 1950s [6]. AI surrounds a wide array of domains, including Natural Language Processing (NLP), Robotics, Speech Understanding, Neural Networks, and Expert Systems [7]. Their applications differ from one field to another depending on the use case application, either in medicine, finance, sports, and increasingly in education. For example, AI is being used in education for personalized learning and academic prediction. A study [8] revealed the effectiveness of various data mining classification algorithms in forecasting student exam outcomes to allow teachers to assist students with unfavorable outcomes.

B. Artificial Intelligence in Education

Artificial Intelligence in Education (AIED) is an interdisciplinary field that refers to the use of AI technologies and techniques in the education domain to enhance learning, instruction, and administrative processes [9]. AIED has been the subject of research for about 30 years. Furthermore, the establishment of the International AIED Society (IAIED) in 1997 marked a significant milestone in the development of this field, further supported by initiatives like the publication of the International Journal of AI in Education [10].

Several studies have analyzed the applications of AIED. For example, the study [11] analyzed many aspects of the applications of AI in college teaching and learning, such as personal tutors, intelligent support for collaborative learning, Intelligent virtual reality, and student-failing prediction. Its results show that those AI applications help students get out of the passive learning state and transform their reflection from solving exercises to solving problems. Besides, This review [9] has also demonstrated that AI is transforming the educational landscape by enhancing both teaching and learning experiences through several AI technologies used in education, including Intelligent tutoring systems, interactive learning environments, adaptive learning systems, curriculum and content development, AI tools that assist educators in administrative tasks, robotics and cobots, and learning assessment tools to track students' performance and improve pedagogical tools. Moreover, In this systematic review [12], authors have categorized the applications of AIED in the realm of Science, Technology, Engineering, and Mathematics (STEM) education under six following categories: learning prediction, intelligent tutoring systems, student behavior detection, automation of assessments and question generation, educational robots, and other like AI textbook and genetic algorithms bases, demonstrating that those AI applications show significant improvements in students' learning performance, affective perceptions, high-level reasoning and students learning behavior and patterns.

AI applications and technology used in education have proven effective in improving and developing education [13], making the learning and teaching process more personalized, efficient, and engaging for students while also providing valuable insights for educators to enhance their teaching practices [10].

IV. AI Applications in Education

Researchers categorized the AI applications based on their literature review findings. From this, a synthesis of the findings was constructed by grouping applications with similar functionalities. While each application possesses unique features, they collectively fall under broader categories. Table II presents our synthesis of findings of AI applications, organized into four main categories: profiling and prediction, Intelligent Tutoring Systems (ITS), automation, and educational robots and chatbots. Each category is followed by its sub-categories, a brief description of its respective applications, and shared features that describe the elements that those sub-categories shared under their respective application.

Table II. Categorization of AI Applications in Education

Category	Sub-category	Description	Shared feature	References
Profiling and Prediction	• Predict and detect students' behavior patterns. • Learning prediction • Modeling learning behavior • Learning performance prediction • At-risk student prediction	Systems that analyze educational data to predict students' performance, behavior, and learning outcomes.	Data-driven insights for enhancing educational outcomes.	[2], [3], [8], [9], [10], [11], [12], [14], [15], [16], [17]
Intelligent tutoring systems (ITS)	• Adaptive systems • Personalization of learning path • Intelligent tutors • Instructional learning delivery • Resource recommendation	Platforms that provide personalized instruction and feedback to students based on their learning needs.	Customization of the learning experience to suit individual student needs.	[2], [3], [7], [9], [10], [11], [12], [14], [15], [18]
Automation	• Student behavior monitoring • Automated assessment • Automated questions generation • Automated learning process model • Automated grading	AI-driven automation of administrative and instructional processes to enhance efficiency and learning outcomes.	Automation of assessment and evaluation.	[2], [7], [9], [10], [12], [14], [17], [18]
Educational robots and chatbots	• Programming robots • Social robots • Robots as teacher assistants and colleagues • Chatbots	Robots are designed to interact with students and teachers.	Interactive and engaging learning through AI robots and chatbots.	[3], [7], [9], [10], [11], [12], [14], [19], [20]

A. Profiling and prediction

Profiling and prediction are mostly used in AIED as AI application. Profiling consists of gathering and analyzing the diver's student data, like academic progress, learning preferences, and behavioral patterns [10]. Using such data, prediction systems aim to forecast students academic performance and identify underperforming students [21], which enables teachers to anticipate student outcomes and identify potential learning risks [12], [14].

In this study [10], a systematic literature review of the applications of AI in higher education, the implementation of profiling and predicting includes using AI for admission decisions and course scheduling, drop-out and retention prediction, and the development of models to forecast academic achievement.

Another study [12] identified two main applications of profiling and prediction: the learning prediction that covers the prediction of both learning performance and at-risk students, and student behavior detection which consists of analyzing and monitoring student behavior.

B. Intelligent tutoring system

Intelligent tutoring systems (ITS) are the main category of AIED, in which designed as AI-enabled platforms to deliver personalized instruction and feedback, in order to facilitate adaptive learning [12], [22]. The latter is an educational approach that considers learners' abilities, knowledge, skills, and emotional states [17]. This approach customized the educational experience for each student by offering tailored learning paths and varying task complexity to suit each student's unique progress and learning pace.

Besides, the experience of instructors utilizing ITS shows an improvement in handling efficiency in administrative tasks and fulfilling their primary teaching roles, through enhanced guidance and instruction to help students reach their learning potential[9]. These systems employ learner models, algorithms, and neural networks to customize the learning path for each student, provide cognitive support, and engage students in interactive dialogues[10].

In this systematic literature review of the application of AIED from 2011 to 2021 [12], identified three sub-categories of ITS applications utilized in STEM education, such as instructional content delivery, suggesting personalized learning paths, and recommending resources.

C. Automation

Automation, as an application of AIED, encompasses a wide array of tasks. These include automating administrative processes, developing curriculum and content, facilitating instruction, enhancing students' learning experiences, and even generating questions or tasks for instructors [9], [12], [14]. Such tasks are accomplished through the use of web-based platforms, educational data mining or computer programs [9]. Consequently, automation not only saves teachers' time and enhances grading consistency [14] but also significantly reduces teachers' workloads by automating tasks such as administrative duties, assessments, feedback, and plagiarism detection through teacher-facing systems [10].

In this research [20] free tools, like MCTest and Moodle are used along with the Virtual Programming Lab (VPD) plugin to showcase how automated evaluations, in a Programming

course can boost pass rates and enhance student achievements significantly. The findings highlight the potential of automation to greatly enhance outcomes.

D. Educational robots and chatbots

Educational robots refer to the adoption of robots in education. Those intelligent agents designed to operate within real-world settings play a crucial role in perceiving, manipulating, and modifying objects [14] to enhance education by facilitating the learning experience for students in an interactive way. Furthermore, the Authors of this study [23] identified educational robotics serve as tools to enrich learning experiences, foster creativity and motivation, support diversity and inclusion, and facilitate teachers' professional development in the realm of STEM education.

Additionally, alongside these tangible AI agents, the role of AI in education extends to virtual assistants such as chatbots. The latter are software applications designed to facilitate online chat conversations through text or text-to-speech, serving as an alternative to direct interaction with live human agents [14]. Those AI-based chatbots provide personalized online learning experiences and transform instructors' roles by enabling chat-based interactions [9].

ChatGPT is a renowned and advanced chatbot platform. It provides adaptive answers to user prompts through the application of Natural Language Processing [19]. ChatGPT offers personalized and adaptive learning experiences by allowing students to interact with educational content customized to their questions. It supports educational learning, complementing the role of teachers rather than replacing them [20].

V. Discussion

From the different papers and studies reviewed, it is evident that the integration of AI in education has the potential to transform the learning experience from the traditional one that relies on passive learning to the modern one that puts students at the center of the learning process, focus on their active participation and exploration to cater to students' learning requirements and enhance their educational outcomes.

Although AI applications have provided a positive impact on education, there are some ethical risks that come with them. For example, the privacy of the data collected through educational AI systems [23] and bias in predictive algorithms [25].

This study recognizes three major limitations: firstly, data was derived from analyzing existing literature reviews rather than conducting a thorough new data collection from vast databases, which may lead to missing the latest developments. Secondly, restricted access to global data and institutional resources has hindered our capacity to collect a complete dataset thus limiting the scope of the study. Lastly, ethical considerations regarding the use of AIED applications were not explored in this study.

In future studies it would be beneficial to broaden the scope of the search database to include empirical research in order to address these limitations. Additionally future investigations should delve into the considerations surrounding AIED with a focus, on issues related to data privacy and biases in predictive algorithms.

VI. Conclusion

The review highlights four applications of AIED that have been widely applied to education: first, profiling and predicting systems help teachers monitor students' performance and identify students at risk of dropping out [12], [26] so that teachers can provide the correct intervention to help the students succeed in their year. Second, ITS improves student engagement and performance by personalizing lessons to meet individual student needs [17]. Third, automation saves teachers time, enhances grading, and reduces teachers' workloads through the automation of administrative tasks, assessments, and feedback [10]; because of this, teachers can focus more on teaching. Finally, educational robots and chatbots provide instant feedback to interact with teachers' and students' questions, promoting active learning, critical thinking and inquiry-based learning [23].

Those applications contribute to more efficient learning processes and support a shift toward student-centered learning approach by providing personalized learning paths, adaptive instruction, and real-time feedback [10]. Those AI technologies enable a more flexible and tailored approach to education, allowing students to engage with the material in ways that suit their needs.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

The authors wrote, reviewed and edited the content as needed and they have not utilised artificial intelligence (AI) tools. The authors take full responsibility for the content of the publication.

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The authors have no conflicts of interest to declare that are relevant to the content of this article.