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Strategies for Employing Artificial Intelligence (AI) Technologies in the Development of Mathematics Teaching: Challenges and Future Prospects

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Abstract

This research aimed to identify the most important strategies used in employing artificial intelligence (AI) applications and technologies in mathematics teaching and to explore the most significant challenges and future opportunities associated with them. To achieve the research objectives, the researcher used a documentary analytical approach by collecting information and data related to the research topic from several Arabic and foreign sources, discussing them, and comparing the results, rather than conducting a field experiment. The results showed that (AI) technologies are important tools in mathematics teaching, as several applications make learning mathematics more enjoyable for students. Furthermore, (AI) can help teachers use modern teaching methods. However, teachers and students face many problems due to the incorrect use of (AI) technologies and applications. These problems include inadequate teacher training, weak infrastructure, and various technical issues, as well as problems related to security and privacy. This research concluded that using AI technologies and applications will not replace teachers but will enhance their role.

Keywords: Artificial intelligence (AI), Mathematics Teaching, Educational Technology, Challenges, Future Vision.

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استراتيجيات توظيف تقنيات الذكاء الاصطناعي في تطوير تدريس الرياضيات: التحديات والافاق المستقبلية

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الملخص

هدف هذا البحث الى التعرف على اهم الاستراتيجيات المستخدمة في توظيف تطبيقات وتقنيات الذكاء الاصطناعي في تدريس الرياضيات واستكشاف اهم التحديات والفرص المستقبلية المرتبطة بها، ولتحقيق اهداف البحث استخدمت الباحثة المنهج التحليلي الوثائقي وذلك بجمع المعلومات والبيانات المرتبطة بموضوع البحث من عدة مصادر عربية وأجنبية ومناقشتها ومقارنة نتائجها بدلا من القيام بتجربة ميدانية. اظهرت النتائج ان تقنيات الذكاء الاصطناعي تعتبر من الأدوات المهمة في تدريس الرياضيات وذلك باستخدام عدة تطبيقات تجعل تعلم الرياضيات أكثر متعة بالنسبة للطلبة بالإضافة الى انه يمكنه مساعدة المعلمين على استخدام طرق تدريس حديثة، ومع ذلك يواجه المعلمين والطلاب العديد من المشاكل بسبب استخدامهم لتقنيات وتطبيقات الذكاء الاصطناعي بطريقة خاطئة، وهذه المشاكل تتضمن ضعف تدريب المعلمين، ضعف البنية التحتية، بعض المشاكل التقنية وكذلك مشاكل تتعلق بالأمان والخصوصية. ولخص هذا البحث ان استخدام تقنيات وتطبيقات الذكاء الاصطناعي لن تحل محل المعلم ولكن تعزز دوره.

الكلمات المفتاحية: الذكاء الاصطناعي، تدريس الرياضيات، تكنولوجيا التعليم، التحديات، الرؤية المستقبلية.

1. Introduction

In recent times, the world has witnessed rapid advancements in the use of modern technologies, leading to developments in the educational process.

Mathematics is one of the sciences affected by these developments. Therefore, mathematics teachers must keep pace with these advancements and update their teaching methods, moving away from traditional approaches. For this reason, mathematics curricula

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in particular, must consider the evolving use of modern technologies to encourage interactive learning among students.

Mathematics is a fundamental science upon which other disciplines, such as engineering, economics, statistics, and chemistry. It encourages creative thinking and analytical skills, which in turn help individuals, solve problems. With the emergence and development of technology, mathematics plays a crucial role in most of these fields. Numerous new branches of mathematics have emerged and the primary goal of learning and teaching mathematics has become developing comprehension and problem-solving skills [1].

Artificial intelligence (AI) is a knowledge science and a modern technology that supports and develops the educational process, transforming it from rote learning to creativity, interaction, and skills development. (AI) based on the premise that it is possible to simulate the human mind through the use of systems and technological devices that understand human intelligence via computer programs capable of mimicking intelligent human behavior [2]. Artificial intelligence (AI) is described as the science of making machines think like humans, in other words, a computer with a mind. (AI) defined as "a field of science and technology that draws on multiple disciplines, including computer science, biology, psychology, linguistics, mathematics, and engineering. The aims of Artificial Intelligence (AI) are to understand the nature of human intelligence and simulate intelligent human behavior through computer programs" [2]. The use of artificial intelligence (AI) applications and technologies in mathematics teaching not only improves academic performance but also helps motivate students and increase their drive to learn. However, these applications face several obstacles, including teachers' lack of experience in using these technologies, technical problems that arise, limited resources in educational institutions, and issues related to privacy, security, and their implementation within educational institutions.

For this reason, this study was prepared to examine the extent to which these tools and techniques can be applied in classrooms in order to develop and facilitate the teaching of mathematics for teachers and to make mathematics easier for students to understand.

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2. Research Problem and Questions

2.1 Research Problem

This research explores the obstacles and opportunities for integrating artificial intelligence (AI) into mathematics education, aiming to improve its quality and develop more interactive teaching methods for students. Although mathematics is a fundamental science in most countries, there is a deficiency in academic achievement and a lack of student understanding of its basic principles. This leads to difficulties in connecting different mathematical concepts and a lack of comprehension of fundamental mathematical principles. Given that mathematics is the cornerstone of other sciences such as computer science, chemistry, statistics, and physics, this decline in achievement in these subjects may be a contributing factor. After investigating this problem, we observed that modern technologies can improve academic achievement in mathematics, and that the use of (AI) applications has a positive impact on academic performance and satisfactory outcomes.
Therefore, the primary objective of this research is to identify how to integrate AI into mathematics teaching and improve the educational achievement of school students [3].

2.2 Research Questions

- What are the main challenges teacher's faces in integrating artificial intelligence (AI) technologies with traditional methods, and how can it be overcoming?
- What are the most interactive programs and applications for developing mathematics teaching using AI technologies?
- What are the most important strategies that can be adopted for integrating AI technologies into mathematics teaching?

3. Research Objectives

- To explore the most significant challenges faced by teachers in integrating AI technologies into mathematics teaching.
- To identify the most effective AI technologies and applications for teaching mathematics, and to explore how they can be integrated with traditional teaching methods to meet the needs of students and teachers.

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- Developing strategies for using and integrating artificial intelligence (AI) and traditional teaching methods, with a focus on using it to increase interactive learning.

4. Significance of the Research

This research promotes the use of modern technologies and keeps pace with the technological age, moving away from traditional methods. It helps increase academic achievement in mathematics through engaging approaches, enhances problem-solving and decision-making skills among teachers, and encourages collaboration between academic institutions. Furthermore, it contributes to improving the quality of education and developing students' knowledge skills, and inspires innovation in designing and integrating AI-based educational tools into the learning process.

5. Methodology

This research employs an analytical and documentary approach, relying on a review of Arabic and English literature related to the application of artificial intelligence (AI) in mathematics education. It highlights the challenges and future opportunities in this field, focusing on studies published between 2021 and 2025. The research relies on analyzing and compiling the results of these studies rather than conducting a field experiment. This research gathers its information from numerous foreign and Arabic academic sources, including:

Scientific papers and research published in peer-reviewed journals related to AI technologies in mathematics education.

Master's and doctoral theses. Data will be collected by formulating specific research questions on the topic. Additionally, academic databases including Google Scholar, Research Gate, and JSTOR will be searched. Studies and researches related to AI and its integration into mathematics education will be selected based on several criteria, including publication date (with a preference for recent studies) and the reliability of the source.

5.1 Analysis Methods

The analysis utilizes data from previous studies, case studies, and a review of numerous research papers in both Arabic and English to identify key points, trends, challenges, and future opportunities

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related to the application of AI technologies in mathematics education. This information organized into a section summarizing the findings of each study and comparing them with the results of the current study.

6. Previous Studies

Hwang and Tu (2021) [4]: This research aimed to explore how to employ artificial intelligence (AI) technologies in the mathematics teaching process and how to increase innovation in its teaching. A descriptive approach was used with secondary school students in Medina, and the random sample consisted of 150 male and female teachers. The results showed that the teachers' use of AI applications was moderate, and that they encouraged their use. However, there were several challenges to their application. The research also recommended the need to expand the use of these modern technologies.

Tokanov et al. (2022) [5]: This study aimed to determine the current state of information and communication technology (ICT) integration in mathematics education in public schools. The research employed a descriptive-analytical approach, utilizing a questionnaire distributed to 203 teachers in Ma'an. The results showed that teachers' use of technology was moderate, but they generally held a positive view of its use. However, weak infrastructure, along with numerous technical, training, and administrative challenges, limited its integration into the teaching process. The study recommended the need for teacher training on modern technologies, technical support, equipped laboratories, and a reduction in administrative time constraints for mathematics teachers.

Al-Shidi and Al-Saidi (2022) [6]: This research employed a quantitative descriptive methodology, distributing 24 analytical cards across five domains in basic education schools in the Sultanate of Oman. The primary objective was to integrate artificial intelligence (AI) concepts into the mathematics curriculum. The results revealed a low level of AI integration, ranging from 0.30% to 8.80% in student textbooks and activities for grades 7 and 8. The research recommended the inclusion of AI concepts in the curriculum and the provision of teacher training on their application.

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Alrwaished (2023) [7]: This study aimed to explore the extent to which mathematics teachers in Kuwait are familiar with using artificial intelligence (AI) technologies and applications in their teaching. It also sought to identify the challenges teachers face in implementing these technologies. The research employed an analytical classroom approach, distributing a questionnaire to 337 teachers. The results showed that teachers utilize modern teaching technologies and AI to a limited extent, despite their awareness of the concept and its applications. Additional obstacles included insufficient time allocated to mathematics teachers, a dense curriculum, and a lack of adequate student training. The research recommended developing curricula that incorporate modern technologies.

Al-Rakhis and Al-Hassan (2024) [1]: This research also identifies future challenges and opportunities. A documentary analytical approach was employed, gathering information from reliable sources such as Google Scholar and Research Gate. The results showed that integrating modern Technology presents significant opportunities for student learning and improved teaching methods. However, the research also highlights obstacles related to security, privacy, and the difficulty of assessment, suggesting that the complete replacement of teachers by artificial intelligence (AI) is unlikely [1].

The research of [8] aimed to reveal the reality of using artificial intelligence (AI) in teaching mathematics from the perspective of female teachers in general education and the obstacles to its application. The descriptive survey method was used with a sample of 75 teachers in the Asir education department, and a questionnaire consisting of 51 statements was prepared, divided into two parts: one related to community characteristics and the other related to the research goals, composed of three axes. The results indicated a high level of response across all axes, and that applications of artificial intelligence (AI) encourage self-learning, make learning more enjoyable, and enhance digital learning skills. The research recommended providing remedial activities using artificial intelligence (AI) applications and raising awareness of its importance and skills, as well as establishing specialized training institutes and centers.

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The aim of [9] is to understand artificial intelligence (AI) in terms of its concept, types, various fields of applications, and how it can be used in mathematics education. It also explores the advantages of using AI applications in mathematics teaching, provides examples of such applications, and examines their future prospects, as well as privacy, security, and ethical considerations.

Dokaly and Al-Dwibi (2024) [10]: This research aimed to focus on the challenges facing the use of artificial intelligence (AI) techniques in teaching mathematics, as well as their impact on students compared to traditional teaching methods. Data analyzed to assess the effectiveness of using modern technologies in teaching mathematics and enhancing student understanding by reviewing previous studies. The results showed that teaching using modern methods positively affects the rapid comprehension of mathematical material, despite the existence of several obstacles such as insufficient training and poor data quality. The research recommended the importance of using modern technology in teaching mathematics.

Opesemowo (2025) [11]: This research examined the advantages and challenges of integrating artificial intelligence (AI) into mathematics education. This research concluded that there are numerous concerns regarding security and privacy in the use of artificial intelligence (AI) technologies. It highlighted the increasing importance of personalized learning, adaptive assessment, and real-time feedback. Despite several drawbacks, such as reduced creativity and problem-solving skills, leveraging the potential of mathematics in teaching requires ethical awareness and strategic implementation to mitigate potential risks.

Badran (2025) [12]: This research aimed to examine the current state of using modern teaching technologies, such as artificial intelligence (AI) and its applications, in preparing mathematics students at the College of Education, as well as future opportunities, from the perspective of faculty members regarding teaching methods and curriculum development in mathematics. The descriptive method used, and data were collected through a questionnaire applied to a sample of 73 faculty members in the fields of curriculum and methods of teaching mathematics and mathematics. The results showed a variation in the awareness of faculty members regarding artificial intelligence (AI) applications

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and a difference in their opinions about its importance in preparing mathematics teachers and its actual use. The respondents agreed on the importance of setting requirements to ensure the effectiveness of applications, despite varying challenges. They generally agreed on the feasibility of the anticipated future vision for using artificial intelligence (AI) technologies in mathematics teacher training.

Agha (2025) [13]: The main objective of this research was to determine the extent of primary school teachers' proficiency in using artificial intelligence (AI) technologies in Tartu. The descriptive-analytical method used, and the sample size was 427 teachers. The questionnaire contained 35 items. The research found that teachers had an average level of skills and emphasized the importance of using artificial intelligence (AI) to enhance the educational process. The research recommended providing training programs to enhance teachers' skills in employing artificial intelligence (AI) in education.

7. Discussion and Results Based on Previous Studies

Although studies have highlighted the importance of employing artificial intelligence (AI) technologies in mathematics teaching and using its applications, there is a lack of direct engagement from teachers. Furthermore, studies have shown a failure to incorporate AI concepts and a deficiency in applied research measuring the actual impact of adopting modern teaching technologies, thus limits the teacher’s ability to effectively employ these technologies. Most studies also relied on a descriptive-analytical approach, focusing on measuring teachers' attitudes rather than their skills. While some documentary studies offer valuable insights, they lack field experience data. Therefore, current research characterize by a focus on theoretical knowledge and a lack of practical experience. Consequently, it is essential to combine field experience with theoretical research to bridge the gap between theoretical analysis and field-testing.

8. Finding

8.1 Regarding the First Research Question:

What are the main challenges teacher’s faces in integrating artificial intelligence (AI) technologies with traditional methods, and how can these challenges be overcome?

The results showed that the most obvious challenges included:

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- Many teachers lack training in using AI technologies, resulting in a lack of awareness regarding their application.
- One of the biggest obstacles to using artificial intelligence (AI) applications in mathematics education is the weak infrastructure and the lack of available equipment and laboratories to stimulate the educational process.
- The inability of most teachers to abandon traditional teaching methods and the lack of encouragement to use modern technologies.
- Inadequate technical support, which wastes time and conflicts with class schedules.
- Students' fear of privacy and the potential harm of using modern technologies.

Studies, such as those by [4] and [8], confirmed that these problems negatively affect the adoption of modern technologies in teaching. To overcome these challenges, the study recommends the following:

- Conducting workshops and training programs for teachers to develop their skills in using artificial intelligence (AI) technologies.
- Developing the infrastructure by providing schools with the necessary technologies and modern programs that are compatible with contemporary teaching methods, such as equipping computer labs and providing internet service.
- Transforming traditional teaching methods by exploring the use of modern technologies through supporting positive experiences and exchanging best practices among teachers.
- Ensuring regular maintenance through the formation of specialized teams to assist teachers in resolving technical issues.
- Conducting workshops on how to protect student data and privacy when using artificial intelligence (AI) technologies.

8.2 Regarding to the Second Research Question:

What are the most interactive programs and applications for developing mathematics teaching using AI technologies?

Findings of Previous studies indicate that many smart learning programs and interactive math problem-solving tools are among the

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most effective tools for improving mathematics teaching. Studies by [1] and [9] have shown that these applications facilitate the solving of complex mathematical problems and equations, enable students to learn easily, and provide immediate feedback that improves academic performance. After reviewing numerous references and previous studies that addressed the use of artificial intelligence (AI) applications in mathematics teaching, the following tools were identified as the best AI-powered tools for teaching and learning mathematics:

- GeoGebra is a program for creating graphs and polygons of all types.
- Math Type is a program for writing mathematical equations in Microsoft Word.
- MATLAB is a program that simplifies complex mathematical and geometric calculations.
- World of Mathematics is a program that contains explanations of lessons and solved exercises for middle and high school students [14].
- Math Solver is a program that helps students understand how to solve mathematical equations systematically, rather than simply providing the final answer.
- Photo Math App is a program used to take a picture of complex problems and solve them with systematic explanations.

Criteria for choosing the best math problem-solving apps:

- They should support all areas of mathematics.
- Ensure the software is free and unpaid.
- The software should be user-friendly and straightforward.
- Choose software that supports different languages.
- It is preferable to choose software and apps that work offline.

8.3 Regarding the Third Research Question:

What are the most important strategies that can be adopted to integrate (AI) technologies into mathematics education?

The results showed that the most effective strategies include:

- Utilize both modern and traditional methods in the educational process, particularly in teaching mathematics.
- Adaptive learning :using methods that suit the student.

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- Employing performance analytics and intelligent feedback systems to assess and determine the extent of academic achievement improvement.

Badran (2025) [12] emphasized the importance of integrating AI into mathematics teacher's training programs to equip them with the skills to effectively use these strategies.

9. Conclusion

This research explores strategies for employing artificial intelligence (AI) applications and technologies in mathematics teaching, given the rapid development of these applications and technologies and their potential to radically transform mathematics teaching methods and improve the quality of learning and teaching. Numerous studies have demonstrated that (AI) can help transform the educational environment into a more interactive, exploratory, and integrated one. Despite these advantages, several challenges exist when using these technologies, including inadequate teacher training, weak infrastructure in educational institutions, and privacy and security concerns. This research identifies several applications and technologies that can be used in mathematics education and learning. It employs an analytical and documentary approach, drawing on a review of numerous Arabic and international studies, comparing and discussing them with the current research.

The results show that these technologies and applications are of great importance in mathematics teaching. However, this does not mean they can replace human teachers; rather, they should be tools used by teachers in their lessons in an appropriate manner.

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