

Improving The Effectiveness of Mathematics Learning Through Artificial Intelligence: Literature Review

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Article Info	ABSTRACT
Article history: Received 2024-06-21 Revised 2024-08-27 Accepted 2024-08-28 Keywords: Artificial Intelligence Mathematics Learning Technology	Industrial Revolution 4.0 has fundamentally transformed the educational landscape. Rapid advances in technology, especially artificial intelligence (AI), demand significant curriculum adaptations. Mathematics, as the foundation of science, is the main focus in efforts to integrate AI into the learning process. This research aims to examine in depth the effect of applying AI in mathematics learning on students' learning capacity. Through a comprehensive literature study referring to various scientific journals and Google Scholar articles, this research analyzes various aspects related to the application of AI in mathematics learning. Analysis includes mapping trends in AI implementation, evaluating the effectiveness of various AI approaches, identifying factors that influence successful implementation, and exploring the positive and negative impacts of AI on the learning process. The findings of this research show that the application of AI in mathematics learning has enormous potential to increase student learning motivation, personalize learning, and deepen understanding of concepts. However, research also identifies a number of challenges, such as gaps in technology access, the need for appropriate pedagogical development, and the potential for AI to replace teachers' roles. Based on these findings, this research concludes that integrating AI in mathematics learning requires careful planning and strong collaboration between educators, technology developers, and policymakers. The implications of this research include the importance of flexible curriculum development, continuous teacher training, and the provision of adequate technological infrastructure. <i>This is an open-access article under the CC BY-SA license.</i> 
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1. INTRODUCTION

The Industrial Revolution 4.0 has fundamentally transformed the world landscape, giving rise to a new era marked by rapid advances in digital technology. One of the most prominent and significant technologies is artificial intelligence (AI). AI's ability to process

data on a large scale, learn from patterns, and make intelligent decisions has opened up new opportunities in various fields, including education [1], [2], [3], [4].

In the context of learning, AI offers enormous potential to revolutionize the way we learn. This technology enables deeper personalization of learning, where each student can receive learning materials tailored to their learning style, pace, and level of understanding. In addition, AI can also provide faster and more specific feedback so students can easily identify areas that need improvement [5], [6], [7], [8].

Mathematics, as one of the fundamental scientific disciplines and often considered difficult by many students, is one of the most interesting fields for the application of AI. The complexity of mathematical concepts and variations in student learning styles demand a more flexible and adaptive learning approach. AI can act as a personal tutor who is always ready to help students understand difficult concepts, provide additional practice, and answer questions in real-time [9], [10].

Applying AI in mathematics learning offers several potential benefits that can transform the educational experience for students. One of the primary advantages is the personalization of learning. AI can analyze each student's progress and adapt the learning materials to meet their individual needs, ensuring that students engage with content at their own pace and according to their specific strengths and weaknesses. This personalized approach makes learning more effective and engaging, as students are more likely to interact with material that is tailored to their unique requirements. Additionally, AI provides quick and specific feedback, which can significantly enhance students' motivation. When students receive immediate feedback on their performance, it not only helps them understand their mistakes but also gives them a sense of accomplishment, thereby encouraging a more proactive and confident approach to learning [11], [12], [13].

Another significant benefit of integrating AI into mathematics education is the development of critical thinking skills. AI-powered tools can be designed to create complex, thought-provoking tasks that challenge students to think critically and creatively to solve mathematical problems. These tasks push students beyond rote memorization and simple calculation, encouraging them to explore various problem-solving strategies. Moreover, AI has the potential to improve learning accessibility, particularly for students with special needs [11], [14], [15], [16], [17]. For instance, AI can offer customized support to students with learning disabilities, providing alternative ways to access and comprehend learning materials. This increased accessibility ensures that all students, regardless of their abilities, have the opportunity to participate in the learning process, thereby promoting inclusivity and equal educational opportunities. However, amidst the great potential offered by AI, several challenges need to be overcome. One of the main challenges is the digital divide that still exists in many countries, which can hinder students' access to AI technologies. In addition, concerns about replacing the role of teachers with AI also need to be considered [16], [17].

To maximize the potential of AI in mathematics education, it is crucial to strike a balance between leveraging technological advances and addressing the inherent challenges. While AI can significantly enhance learning experiences and accessibility, it should not replace the irreplaceable human element that teachers bring into the classroom. Teachers play a vital role in mentoring, inspiring, and understanding the emotional and social needs

of students in areas where AI currently falls short. By combining the strengths of AI with the unique capabilities of educators, a more holistic learning environment can be created, one that not only enhances critical thinking and problem-solving skills but also nurtures students' personal and emotional development. This blended approach ensures that technology serves as a tool to support and enrich education rather than overshadowing the essential human interaction that is at the heart of effective teaching and learning.

This research aims to examine in depth the effect of applying AI in mathematics learning on students' learning capacity. Through a comprehensive literature study, this research will analyze various aspects related to the application of AI in mathematics learning, starting from application trends the effectiveness of various approaches, to the challenges and implications that arise. Thus, it is hoped that this research can contribute to the development of more effective and efficient mathematics learning strategies in the digital era.

2. METHOD

This research is grounded in a comprehensive literature study, which involves an extensive review of existing academic sources, including peer-reviewed articles, scientific publications, conference proceedings, and other scholarly materials. The primary aim of this literature review is to gather, evaluate, and synthesize existing knowledge and findings related to the application of Artificial Intelligence (AI) in mathematics education. By systematically reviewing these sources, the study seeks to identify the current trends, theoretical frameworks, methodologies, and outcomes associated with integrating AI into mathematics learning environments. This approach ensures a thorough understanding of how AI can be used to enhance mathematics education and what challenges may arise from its implementation.

The research process involves several key steps, beginning with the identification of relevant literature. A wide range of databases and academic journals are searched using specific keywords and phrases related to AI and mathematics learning. Once relevant sources are identified, they are carefully analyzed to extract pertinent information about the use of AI technologies, their effectiveness in teaching and learning mathematics, and the various approaches employed by different studies. The analysis also includes a critical evaluation of the methodologies used in these studies, as well as an assessment of their findings. Following the identification and analysis phases, the research moves into a synthesis stage, where the insights gained from various sources are integrated to provide a comprehensive overview. This synthesis not only highlights the potential benefits of AI in mathematics education but also brings to light any gaps in the current research, thereby paving the way for future studies in this field.

3. RESULTS AND DISCUSSION

3.1. Understanding Artificial Intelligence (AI)

Artificial Intelligence (AI) is a specialized branch of computer science that is dedicated to the development of intelligent systems capable of simulating human thought processes and behaviours. These systems are designed to perform complex tasks with high

levels of efficiency and effectiveness, emulating cognitive functions such as learning, reasoning, and problem-solving. According to García-Sánchez et al. [18], the rapid advancements in technology have significantly transformed various aspects of human life, leading to innovations that enhance both the functionality and interactivity of everyday systems. The current focus in the technological domain is on harnessing the intelligence inherent in both living and non-living entities, thereby embedding such intelligence into systems that are capable of being scientifically validated and tested. This approach not only aims to improve the practical utility of AI systems but also to ensure their reliability and adaptability in real-world applications. By integrating AI into various fields, the goal is to create adaptive and autonomous systems that can respond to a wide range of scenarios, ultimately enhancing the quality of human-computer interactions and expanding the capabilities of technological solutions.

Hanila and Alghaffaru [19] describe artificial intelligence (AI) as a system developed through rigorous research and innovation modelled using machines and computers, which can exhibit intelligence comparable to, or even exceeding, that of humans. This is characterized by adaptive capabilities, decision-making processes, cognitive functions, and the ability to learn from experiences. AI systems are engineered to mimic human intelligence by performing tasks that traditionally require human intervention, making them crucial in a wide range of applications across various industries.

The impact of training on the use of artificial intelligence is profound, beginning with an enhanced understanding of technology. AI education helps students grasp the foundational concepts of AI and related technologies, such as machine learning and data analysis. This foundational knowledge provides students with a deeper comprehension of how these technologies operate and their potential applications in diverse fields, from healthcare to finance. Understanding these concepts enables students to see the practical applications of technology in solving real-world problems.

Furthermore, AI education plays a pivotal role in improving technical skills. In today's digital era, possessing technical proficiency is essential. AI education equips students with valuable skills in computing, programming, and statistical analysis. They learn to use programming languages associated with AI, such as Python, which are crucial for developing AI applications. These technical skills not only prepare students for the current technological landscape but also empower them to contribute to future advancements.

AI education also fosters creativity among students. By understanding the capabilities and limitations of AI, students are encouraged to explore innovative solutions and projects. They can design new applications, programs, or tools that leverage the potential of AI, thereby enhancing their creative thinking and problem-solving abilities. This creative exploration is essential for innovation, driving the development of new technologies and applications that can benefit society.

Another significant impact of AI education is the introduction to careers in technology. Exposure to AI helps students identify various career opportunities in technology-related fields. This awareness can motivate them to pursue further education in these areas and consider career paths in industries that are increasingly integrating AI, such as robotics, data science, and software development. By understanding the vast career

prospects associated with AI, students can make informed decisions about their future professional endeavours.

AI training also enhances students' problem-solving skills, particularly for advanced and complex issues. AI is often used to address intricate problems that require sophisticated algorithms and computational power. Through training, students learn to apply AI principles in designing effective solutions, which sharpens their analytical and critical thinking skills. This capability is invaluable in a world where problem-solving is a key component of innovation and development.

Interdisciplinary collaboration is another benefit of AI education. Students are encouraged to integrate AI concepts with other scientific disciplines, such as social sciences, natural sciences, or health sciences. This interdisciplinary approach fosters collaboration, leading to innovations that are more diverse and applicable across different fields. It allows students to see the broader implications of AI and how it can be used to enhance understanding and outcomes in various areas of study.

Digital literacy is also significantly improved through AI education. As the world becomes more digital, understanding the technical and ethical aspects of technology use is crucial. AI education helps students comprehend issues related to privacy, security, and the social impact of technology. This awareness is critical in ensuring that technology is used responsibly and ethically, safeguarding individuals and society as a whole.

Additionally, AI education emphasizes the importance of understanding the ethics and responsibilities associated with technology. Students learn about potential ethical dilemmas, such as biased algorithms and privacy concerns, and are encouraged to think critically about the societal impact of AI. This ethical education is crucial in developing AI technologies that are fair, transparent, and beneficial to all members of society.

Adaptability is another key outcome of AI training. As technology evolves rapidly, AI education helps students develop the ability to adapt to these changes, fostering a mindset of lifelong learning. This adaptability ensures that students remain relevant in their careers, continually updating their skills and knowledge to keep pace with technological advancements.

Finally, AI education prepares students for the future by equipping them with the skills needed in an increasingly automated and connected world. As AI becomes more prevalent across various industries, students who are trained in AI are better positioned to face future challenges. They are prepared to thrive in environments that rely heavily on automation and intelligent systems, ensuring that they can contribute effectively to the technological advancements shaping our world.

According to the study conducted by Zahara et al. [20], the use of artificial intelligence (AI) technology in mathematics education plays a crucial role in enhancing student learning activity. This is because AI can create a more interactive learning environment that focuses on individual needs, enabling students to participate more actively in the learning process. The study highlights that the integration of AI technology not only helps students understand mathematical concepts better but also increases their motivation and engagement in learning.

Here are some key concepts in the world of AI:

1. Machine Learning (Machine Learning)

This field of AI focuses on developing systems that can learn from data and use that knowledge to complete tasks or make predictions. The more data available, the more accurate the results produced by this system. The system continues to improve in performance as more data is processed.

2. Deep Learning (Deep Learning)

It is a sub-section of machine learning with multilevel artificial neural networks that allows the processing of complex data effectively and accurately, such as images, sounds, and text. Deep learning is very effective for recognizing patterns and making accurate predictions.

3. Neural Network (Artificial Neural Network)

Inspired by the structure of the human brain, ANN is a computing system consisting of elements (nodes) that are connected and have weight values that determine the strength of the connections between the elements. These connections allow ANNs to learn and process information just like the human brain. These networks are trained to process information and learn from data.

4. Natural Language Processing (Natural Language Processing)

This concept focuses on developing systems that can understand and reproduce human language. NLP allows AI to interact with humans naturally, such as in virtual assistants and chatbots.

5. Big Data (Big Data)

AI requires large amounts of data to learn and improve its capabilities. Big data provides a rich source of information to train AI models and make them more accurate.

Apart from the concepts above, AI also involves other fields, such as computer vision, reinforcement learning, and robotics. Understanding these concepts is important to exploit the potential of AI optimally.

3.2. Effectiveness of AI Implementation in Education

The use of artificial intelligence (AI) in individual learning systems has been shown to have a significant positive impact on mathematics learning. AI is able to adjust the learning pace based on each student's understanding, thus creating a more personal and optimal learning process. The application of AI has been shown to expand students' competence in understanding and solving various problems comprehensively. Thus, the integration of technology in mathematics learning not only accelerates the learning process but also creates a conducive learning atmosphere for the mastery of mathematics skills as a whole [21].

In addition to providing benefits to students, AI also acts as an assistant for teachers. Teachers can use AI to develop learning innovations, improve understanding of mathematical concepts, and assist in effective and efficient record management [22]. With the help of AI, teachers have more time to focus on student interaction and development, thus creating a higher-quality teaching and learning process. The application of AI in

mathematics learning marks a new era in education, where technology becomes a powerful tool to lead students toward a deeper and more comprehensive understanding.

The application of artificial intelligence (AI) in the world of education will open up new, innovative ways of learning. AI, known as intelligent machines in animated films, is capable of performing human-like tasks, such as analyzing, solving problems, and even controlling robots [23]. This ability can help improve the teaching and learning process.

Grace et al. [24] say that Artificial Intelligence (AI) can revolutionize education by providing personalized learning experiences, intelligent tutoring, and immersive technology, and AI can be used to create content automatically, such as articles, social media posts, and videos. However, AI must also be used responsibly and inclusively. AI can be used to personalize learning, and it will also develop critical thinking and problem-solving skills that are important for students' future success.

Fauzan et al. [25] said the AI system utilizes learning system innovation with artificial intelligence, providing a personalized learning experience to improve the quality of learning and help students learn more focused and attentively. To find optimal teaching methods, AI can teach individuals and identify problematic areas. AI is able to recognize concepts that are difficult for students to understand.

The implementation of AI in education, especially in mathematics learning, has shown promising results in recent years. Here are some examples of success:

1. Increase Personalization of Learning:

AI is able to analyze individual student data. This data includes students' learning patterns, strengths, and weaknesses. Based on this data, AI can provide personalized learning for each student. AI can help students reach their potential according to their abilities and focus on the areas they need to grow.

2. Increases Student Engagement and Motivation:

The use of AI-based educational games and simulations The use of AI-based educational games and simulations in mathematics has proven effective in encouraging motivation and improving student learning outcomes. This situation can foster student engagement and motivation and encourage them to learn more.

3. Provide Immediate and Real-time Feedback:

The AI system allows students to receive fast and accurate feedback on their work on math problems. This helps students to understand their mistakes quickly and learn from them.

4. Helps Teachers Identify and Help Struggling Students:

AI systems can analyze student performance data to identify those who are experiencing difficulties. Teachers can then provide extra attention and support to these students.

5. Automate Administrative Tasks:

AI systems can automate administrative tasks such as grading, scheduling, and tracking student progress. AI frees up teachers' time from administrative tasks, allows teachers to focus on deeper interactions with students, and provides higher-quality instruction.

The learning process that causes more active learning is the role of artificial intelligence technology. This is because the center of the learning process is entirely on the students. Students carry out learning activities according to their intentions and needs. Apart

from being active, the presence of an artificial intelligence system makes learning more interesting [26]; this is due to the various experiences that students have when using the products they are currently studying in the learning process. Where teachers used to go through the teaching process traditionally, they now use artificial teachers to go through the learning process in a new way.

Examples of artificial intelligence applications in education are the use of several applications/webs, but here are some examples of these applications:

1. A dual-teacher class is a situation where there are two teachers in the class, namely a general class teacher and an Artificial Intelligence-based teacher [27].
2. Digital Reporting Application (ARD) is an online learning result reporting application created by Madrasah under the auspices of the Ministry of Religion of the Republic of Indonesia [28].
3. Rumah Belajar is a website that contains learning material from early secondary education to senior high school or vocational high school. The features of this learning house are learning resources, electronic textbooks, question banks, virtual laboratories, cultural maps, and many others.

Even though AI has great potential to improve various sectors in Indonesia, its implementation is still hampered by obstacles such as the limited expertise of workers in utilizing AI and the lack of capital in developing AI infrastructure. This has resulted in Indonesia lagging in terms of technology absorption compared to other countries in the Asia Pacific [29].

3.3. Positive Impact of Artificial Intelligence (AI) in Education

In the field of education, AI plays a very important role. Within the scope of students, AI helps students make learning more effective, for example, by using ChatGPT. Based on research conducted by Rifky [30], he examined the Populix survey. The survey results showed that GPT chat was in the top position or the most widely used among other AI applications. In ChatGPT, we can get answers to whatever we ask, and of course, it is very helpful for students to find answers to their questions. Not only that, in ChatGPT, we can also help students find additional material and even help them write papers, poetry, rhymes, and so on. This is certainly an added value that will result in a large number of ChatGPT users.

AI can also identify students' needs, including the difficulties they face in learning. Many learning applications apply AI systems, such as the foreign language learning application (Duolingo). In Duolingo, there are certain systems, such as the existence of lives or limits for making mistakes, learning arranged by chapter, there is the repetition of material, game-based learning, interactive multimedia, many choices of languages that users want to learn, and so on. When the user makes a mistake, Duolingo will ask the same question at the end of the session (feedback), which is useful for correcting the mistake (evaluation). Proof that AI is able to analyze errors, make improvements, and analyze their difficulties in learning something.

Apart from students, AI also has a positive impact on teachers; one of the positive impacts for teachers is in the field of administration. A teacher's job is not just to teach. Taking care of administration is also included. AI systems are capable of carrying out administrative tasks such as automating schedules, managing student data, and recording attendance [31], [32]. Of course, it really helps teachers to save time so that teachers can focus on teaching.

This positive impact also applies to mathematics subjects. Mathematics is known as a scary subject and the most difficult. By utilizing AI as needed, mathematics can be a fun subject. To implement the AI system, teachers need to develop it first so that it can be applied in the classroom, for example, by preparing various learning multimedia in the form of educational flash disks, where the flash disk contains many interactive learning videos that make learning mathematics fun.

3.4. Negative Impact of Artificial Intelligence (AI) in Education

The AI system helps and simplifies various educational needs for its users. The presence of artificial intelligence in the world of education opens up new opportunities for students, education staff, and researchers to conduct research more easily and effectively [33], [34], [35]. For example, in mathematical research, AI is becoming a powerful tool, especially for complex statistical data analysis. Its advantages in speed and accuracy help researchers to discover patterns and trends that are difficult to detect with traditional methods.

With the help of technology, students can more easily discover and develop their understanding of complex mathematical concepts [36], [37], [38]. According to Fal, in the digital era, chatbots have emerged as a new phenomenon that allows interactive text-based interactions to help humans obtain information. Users of this artificial intelligence can ask questions and receive answers quickly. For students, chatbots offer the benefit of serving as virtual mentors that aid in understanding concepts and promoting independent learning. However, the use of artificial intelligence to create academic work without proper paraphrasing can lead to plagiarism. In this context, chatbots can also become a negative aspect of AI if used excessively [39], [40]. Therefore, while AI technology presents significant potential in education, it is crucial to apply proper ethical usage to avoid misuse and possible negative consequences.

The existence of chatbots and other AI technology in the world of education has brought a breath of fresh air in terms of easy access to information and learning [40], [41]. However, it is important to remember that this convenience can potentially lead to dependency, which can hinder the development of critical thinking and independent problem-solving skills in students.

Clear evidence of people's enthusiasm for artificial intelligence is the rising popularity of ChatGPT. Within just two months of its launch, ChatGPT reached 100 million active users. This indicates that artificial intelligence is not only in demand but also needed by many people, including in the field of education [42]. In the context of mathematics education, ChatGPT facilitates the learning process by helping students understand complex concepts engagingly and interactively. However, it is important to remember that artificial

intelligence not only brings positive impacts but also has the potential to cause negative effects if not used wisely. Improper use of AI in the learning process can lead to excessive dependency and a potential decline in students' critical thinking abilities. Therefore, proper oversight and guidance are necessary for the integration of AI into educational systems to ensure that this technology is utilized optimally and ethically.

Following are some of the impacts or negative sides of Artificial Intelligence in education:

1. Dependence on AI

When the learning process takes place, and a teacher gives assignments to his students, sometimes we often come across students who always rely on Google to find answers very easily. With very instant and fast results, students get used to relying too much on Google to find answers to each assignment without trying to understand the concepts of the subject matter in depth. This can result in a decrease in students' mathematics skills because they are not used to solving mathematics problems independently.

2. Lack of interaction and collaboration

Excessive use of AI in education can result in reduced direct interaction between teachers and students, whose role is very important in building relationships and obtaining social support. This lack of human interaction can also cause students to feel isolated and disconnected from the teaching and learning process.

3. Digital Divide

Unequal access to AI technology exacerbates existing educational gaps, as students from disadvantaged backgrounds are unlikely to have equal opportunities to take advantage of its benefits. This can cause disparities in mathematical abilities between students, where students who have access to AI technology will understand mathematical concepts more easily than students who do not have access.

4. Limitations in explaining concepts

AI systems are not always capable of providing a deep understanding of complex mathematical concepts. Teachers always play a crucial role in the teaching and learning process, namely explaining concepts, providing examples, and answering students' questions to achieve in-depth understanding.

5. Loss of interest and motivation

Relying too much on AI can make learning mathematics or learning in other subjects uninteresting. Students may lose interest and motivation to learn if they feel they do not need to put in the effort themselves. This can result in a decrease in student learning achievement, especially in mathematics, which requires practice and in-depth understanding.

According to Aji [42], although artificial intelligence (AI) offers many conveniences for teachers and students, excessive use can lead to dangerous side effects, such as dependency. This dependency can make individuals lazy and unaccustomed to completing tasks independently. Over time, this can weaken their confidence in solving problems, ultimately negatively impacting students' critical thinking and independence.

The potential of AI in education is significant in enhancing the quality of learning. However, it is crucial to manage the use of AI wisely to avoid negative impacts. With a balanced and comprehensive approach, we can leverage AI to create a more effective and enjoyable learning environment for students. This approach emphasizes the importance of maintaining a balance between the use of technology and the development of students' fundamental skills in critical and creative thinking.

Teachers play a key role in designing tasks that encourage students to think critically and creatively. For example, teachers can assign projects that require students to collect data, analyze it using AI, and then present their findings orally or in writing. In this way, students not only learn to use AI but also develop higher-level skills such as communication, collaboration, and problem-solving. This approach ensures that technology is used as a tool to enrich learning rather than as a substitute for students' basic cognitive abilities.

3.5. Efforts to Mitigate the Impact of Artificial Intelligence

The application of artificial intelligence (AI) brings many benefits in various fields, including education. However, on the other hand, this AI has negative potential that needs to be watched out for and overcome. The following are several mitigation efforts that can be taken to minimize the negative impact of AI in education:

1. **Develop Guidelines and Regulations**

Establish clear guidelines on the use of AI in education, including ethical standards, data privacy, and accountability. Ensure regulations and guidelines are in line with principles of human rights and social justice. It involves various stakeholders in the process of preparing regulations and guidelines, including academics, educational practitioners, parents, and students.

2. **Increase AI Literacy**

Increasing AI literacy for all interests in the education sector, including teachers, students, parents, and the wider community, and providing training and education about AI, including how to use it responsibly, ethically, and effectively. Raise awareness about the potential negative impacts of AI and how to avoid them.

3. **Ensure Fairness and Inclusivity**

Ensure fair and equitable access to AI technology for all students, regardless of socio-economic background, gender, or ability. It is developing an AI system that is inclusive and free from bias so that it does not harm certain groups. Consider student needs and diversity in the design and implementation of AI systems.

4. **Maximize the Benefits of AI**

They are focusing the use of AI on things that can improve the quality of education (personalized learning, more objective assessments, and support for students with special needs). Leverage AI to help teachers with administrative and repetitive tasks so they can focus more on interactions with students, developing pedagogy, and combining AI with traditional learning methods to create a more holistic and effective learning experience.

5. **Monitor and Evaluate the Impact of AI**

Monitor and evaluate the impact of using AI in the education sector on a regular basis. Identify potential risks and problems that arise due to the use of AI. Make adjustments

and improvements to regulations and guidelines, as well as implement AI based on monitoring and evaluation results.

6. Building Collaboration and Dialogue

We are encouraging collaboration between various stakeholders in the education sector (such as academics, education practitioners, technology developers, government, and civil society). Establish an open and constructive dialogue about how AI can be used in education. Share knowledge and experience on best practices in mitigating the negative impacts of AI.

Some researchers say that overcoming the potential negative impacts of AI requires a series of proactive steps that balance technological advances and traditional educational values [43], [44], [45], [46]. Here are some actions to consider:

- 1) In the era of artificial intelligence (AI), educators need to focus pedagogical development on learning approaches that place humans at the center. AI can be used as an innovative tool to support the teaching and learning process, realized through the application of various appropriate strategies such as Project-based learning and so on.
- 2) Personal information and student data must be kept confidential. This is a key responsibility for policymakers. They must make strict rules and implement the best ways to collect, store, and use student data.
- 3) Artificial intelligence technology opens new horizons in the world of education, offering a myriad of opportunities to improve the quality of learning and achieve optimal results. However, so that AI can be utilized optimally, teachers need to be provided with adequate training. This training should cover several important aspects: A deep understanding of AI, integration of AI in learning, ethics, and responsibility for the use of AI.
- 4) The importance of regularly evaluating the use of AI to determine the impact of using AI in learning must continue to be monitored. The goal is to see if AI helps improve student achievement, make them enjoy learning more, and change the way they learn. This information can then be used to improve AI systems and make them more useful.

The use of AI in the school environment can be an effective supporting tool for improving the quality of teaching and learning. However, in order to maintain academic integrity, transparency and clear guidelines are needed in its use. Schools should create clear guidelines about the permitted uses of AI. Teachers and students should discuss the use of AI openly and honestly. Students should understand what AI tools they can and cannot use, as well as the reasons behind any restrictions. Students need to be honest in their use of AI when working on assignments and understand that AI is a tool to facilitate learning, not replace the learning effort itself [47].

The use of artificial intelligence (AI) technology in education is increasing, offering many opportunities to enhance the learning process. By following the right guidelines, schools can create positive and productive learning environments where AI is used to support learning rather than to facilitate cheating. Proper implementation of AI technology will enrich students' learning experiences and facilitate various innovative learning methods.

Efforts to mitigate the negative impacts of AI are crucial to implement. By doing so, we hope to minimize the potential negative impacts of AI in education while maximizing its benefits to improve the quality of education for everyone. For example, strict supervision and clear policies regarding the use of AI can help prevent the misuse of this technology and ensure that it is used fairly and responsibly.

It is important to remember that AI is a tool, and like any other tool, AI can be used for good or bad purposes. Depending on how we use it, AI can be a powerful force for improving education or, conversely, can exacerbate existing inequalities and injustices in the world. Therefore, the use of AI must be carried out with full responsibility, taking into account the ethical and social implications that may arise.

In this context, we need to use AI responsibly, ethically, and inclusively. Collaboration between educators, policymakers, and technology developers is essential to ensure that AI is used for good and benefits everyone. In this way, we can ensure that AI is not only a tool to improve education but also to create a more just and equitable society.

CONCLUSION

In conclusion, AI in mathematics learning has the potential to revolutionize the teaching and learning process by offering personalized instruction, interactive simulations, and automated assessments. This technology can cater to the unique needs of each student, enhance engagement through visualizations and educational games, and provide accurate feedback, thereby improving the overall quality of mathematics education. Furthermore, AI can expand access to high-quality mathematics education, particularly for students in remote areas.

However, it is crucial to recognize that while AI offers numerous benefits, it also poses potential risks if not used responsibly. Misuse or over-reliance on AI could lead to negative outcomes, such as diminished critical thinking skills or increased inequality. Therefore, careful and thoughtful implementation of AI is essential to harness its advantages and mitigate its drawbacks. By using AI appropriately and ethically, educators can enhance the learning experience and support students in reaching their full potential.

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