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ARTIFICIAL INTELLIGENCE: A FACILITATOR IN ENHANCING MATHEMATICS INSTRUCTION

NARGES YAFTIAN* AND REYHANE NIKNAM OSKOOEI

Abstract. Artificial Intelligence (AI) can be regarded as a companion that enhances the pathway toward a more sustainable and intelligent educational system, facilitating a more enjoyable experience for teachers. By integrating AI technologies into educational practices, both teachers and students can benefit from a more efficient teaching-learning process. To benefit from AI capabilities in the classroom, it is essential for teachers to become familiar with AI-based tools, understand their strengths and weaknesses, and then promote the culture of proper use of these new intelligent tools in the classroom. They should guide students in using AI in the right direction. Students, as novice users of AI, need more support and guidance. Therefore, they should be taught to select the information obtained through AI according to their needs and not to accept everything AI presents easily. Instead, they should carefully evaluate the information obtained with their cognitive skills, especially critical thinking. It should be remembered that AI cannot completely replace human teachers in the classroom. In other words, an AI-supported classroom makes sense with the presence of human teachers; however, AI-based tools can complement the tireless efforts of teachers. This review article is an effort to inform teachers about the operational aspects of AI in mathematics education. In this regard, it practically introduces some AI-based tools along with several examples and presents a sample of AI applications in developing adaptive learning systems.

Keywords: artificial intelligence, the use of artificial intelligence in math education, artificial intelligence-based tools.

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*Corresponding author.

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1. Introduction

So far, there is no unique definition of AI [14, 20, 38]. However, AI can be considered as a set of theories and methods implemented to create machines that are capable of simulating human intelligence [18]. AI is a simulation of human intelligence modeled in the form of a machine and programmed to think like a human [6]. Of course, AI is not an emotionless robot that wants to replace humans, but rather a type of technology that can think [16].

2. The role of AI in education

The vast capabilities of AI [24] enable teachers to collaborate with it as an intelligent assistant, an assistant that can transform the role of the teacher into a facilitator [11, 16]. AI helps teachers conduct the student assessment process more accurately and easily [7]. It can personalize the educational program and content for each student by analyzing the learner's progress and identifying areas where the student has strengths or weaknesses, thereby improving the overall quality of student learning and their learning experience [8, 11, 27]. Additionally, working with an AI tutor can reduce students' social or academic anxiety [29].

AI can assist teachers in identifying the most effective teaching methods based on students' backgrounds and learning histories [7]. However, AI cannot fully replace human teachers in the classroom [14, 33, 35, 39]. In fact, without the presence of teachers, AI loses its fundamental significance [42], because no matter how capable robots are in teaching, their abilities do not equate to the professional capabilities of teachers [24]. Nevertheless, AI can perform many aspects of the teaching-learning process very close to how humans do [11, 16].

The interaction between humans and AI opens new possibilities for students with special needs, serving as an assistant [24, 41]. For instance, research indicates that AI can reconstruct the unique handwriting of individuals with disabilities or impairments affecting their writing abilities. This technology is expected to significantly change the lives of many people who face challenges in communication [24].

The capabilities of AI in education are astonishing, but the challenges it poses should not be overlooked [26, 35]. For instance, reliance on AI technologies used for educational decision-making may raise concerns among parents, administrators, and teachers [26]. Excessive use of AI can lead to dependency and may diminish emotional connections, as robots lack the ability to feel emotions. Another concern for teachers is that although AI-based tools and robots can personalize classroom activities, they cannot monitor and assess each student's progress as comprehensively as human teachers can [35]. Moreover, ethical considerations in the use of AI are often neglected, partly due to a lack of awareness among stakeholders about the AI's limitations. For instance, when AI incorrectly predicts that a particular student will underperform in final exams, such errors can significantly influence how parents and teachers perceive the student's abilities, potentially having a profound psychological impact on the learner. Therefore, it is crucial to avoid basing judgments solely on the outputs of AI-based tools and

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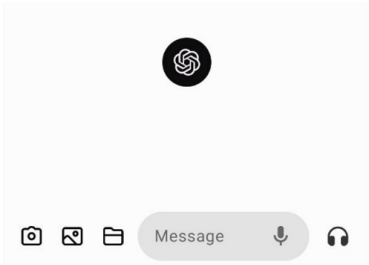
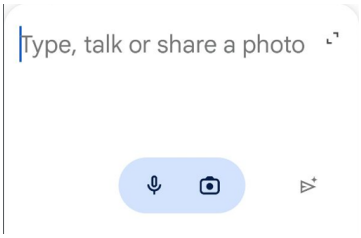
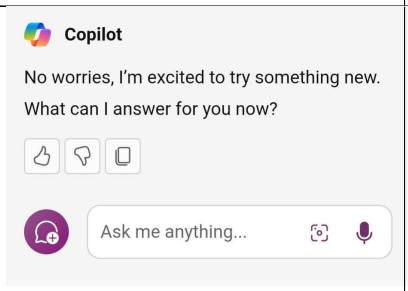
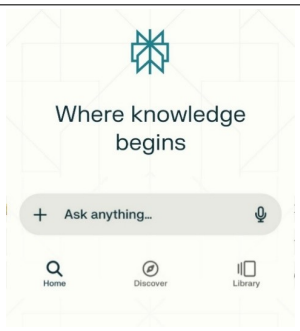
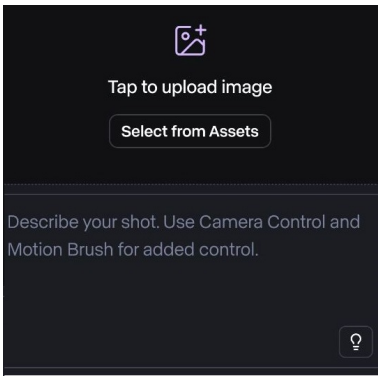
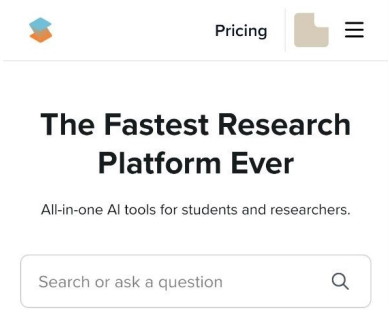
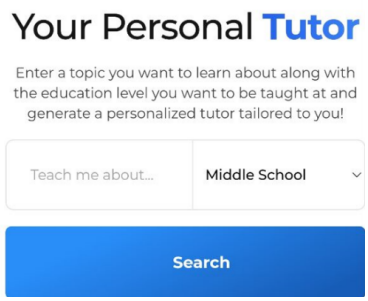
to refrain from making overly generalized statements. Instead, AI should be used as a supportive tool, complemented by human insight and judgment, to ensure fair and effective decision-making [7].

3. The use of AI-based tools in teaching mathematical concepts

The use of AI-based tools can have a positive impact on the process of learning mathematics [6, 19] and enhance the overall quality of the teaching-learning process in mathematics. Therefore, AI can be regarded as an effective educational tool, facilitating teaching and improving student performance in the classroom by increasing their motivation to learn, encouraging participation in challenges, and fostering a spirit of healthy competition [38]. AI can enhance teaching methods by offering various suggestions, making them more attractive and effective. Table 1 presents several AI-based tools that provide different capabilities to users. These capabilities include the ability to exchange information and interact with AI through text, voice, and images.

TABLE 1. Introduction of some AI-based Tools

The name of the tool	A preview of the tool's interface	Some features of this tool
ChatGPT		ChatGPT is an example of a conversational AI chatbot. It enables users to engage in discussions on various topics and obtain information as it understands colloquial language and can provide responses similar to natural conversational speech. With this tool, users can access the best resources for various subjects, facilitating more effective lesson planning. ChatGPT has multiple versions, with the latest being ChatGPT4, which includes image generation capabilities. Additionally, it can translate texts between languages. Users can upload an image or input text to receive its translation.
Gemini		Gemini, formerly known as Bard, is an AI assistant developed by Google's search engine. It enables users to engage in text-based conversations, offering them the opportunity to interact and benefit from its guidance.
Copilot		Copilot, which is integrated with Bing's search engine, also serves as a bridge between the user and ChatGPT4. This AI offers a wide range of features to users. Its distinguishing capability is its ability to design and generate images upon the user's request. This powerful tool can assist users in programming by providing suggestions to complete, correct, and improve written code.

Perplexity		Perplexity is a text-based tool that provides accurate answers to a wide range of questions. With its advanced web search capabilities, this powerful AI delivers precise, comprehensive, and well-documented responses to users.
Runwayml.com		This tool can animate photos or create videos or animations based on the user's description, making education more engaging for students. By providing a detailed description of a situation, users can receive corresponding animations. Additionally, users can upload any desired image to the appropriate section and receive an animation of that image as a short video.
scispace.com		This site provides searchers with access to the latest articles. Users can search for desired content and interact with this powerful AI. What sets this tool apart from others is its ability to conduct a more precise and scientific search among reputable sources. Users can upload any article into this amazing tool and ask the AI to find answers to their questions within the text. Additionally, this AI can summarize articles, search for related content, and explain various parts of the articles.
Llamatutor.com		This advanced AI can answer users' questions at various levels (including elementary, high school, university, etc.) offering responses similar to those of a professional tutor, considering the user's level. In other words, users can indicate the level of response they expect and the AI will provide answers tailored to that level. Additionally, the AI can supply sources for the answers it provides.

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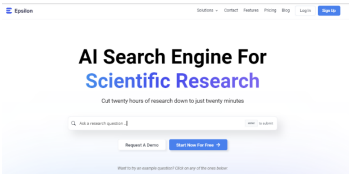
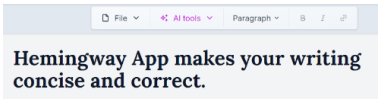
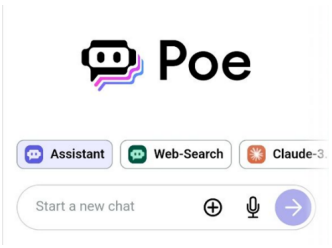
Epsilon-ai.com		This website can extract answers to user questions from a wide range of reputable scientific articles and resources. Users can customize settings to obtain answers from articles published in different years according to their needs. Additionally, by uploading articles to this website, users can receive comprehensive summaries.
Hemingwayapp.com		This powerful AI can review, grade, and proofread scientific texts like an editor. For instance, users can upload their English texts and use this tool to correct them. Professional features of this website include checking adverbs, verbs, writing structure, and vocabulary.
poe.com		This website provides users with access to several new AI-based tools. Another feature offered by this website is text translation. Users can input their text and request translations from the AI and receive the translated text in a short amount of time.

Each AI-supported tool offers various capabilities for teachers. For instance, as a mathematics teacher, we utilized Copilot in Persian to enhance the teaching of radians (figure 1).

FIGURE 1. Conversation with AI in Persian about how to teach the topic of radians

In response to our question, Copilot proposed several creative methods and practical examples to enhance the attractiveness and effectiveness of our teaching. These suggestions included conceptualizing the concept of radians using a circle, incorporating practical examples to demonstrate the presence of radians in the real world, such as in bus or bicycle wheels, employing storytelling techniques in teaching, designing group activities, and utilizing educational videos. Each of these methods offers an engaging approach to teaching the concept of radians.

Copilot includes links to sources at the end of some of the information it provides. These links, displayed as numbered references at the end of sentences, direct users to the original sources of the responses.

One of the useful capabilities of AI is explaining and designing educational games and activities [41]. This approach allows educational content to be taught indirectly and practically to students [3]. Additionally, AI can create stories related to lesson topics, connecting the story's theme to real-life situations and embedding the intended message in students' minds indirectly [31]. For instance, In response to our request for a story about the concept of radians, Copilot suggested a story titled Adventure in the Amusement Park. This story explains the application of radians through the Ferris wheel at an amusement park, offering a creative way to amuse the classroom.

In addition to providing textual information, AI can create images for various topics. To utilize this capability, the users simply need to describe the desired situation to the AI. Additionally, specific elements can be added to or edited in the images. For instance, we asked Copilot to create images illustrating the role of radians in the design of bicycle wheels (figure 2).

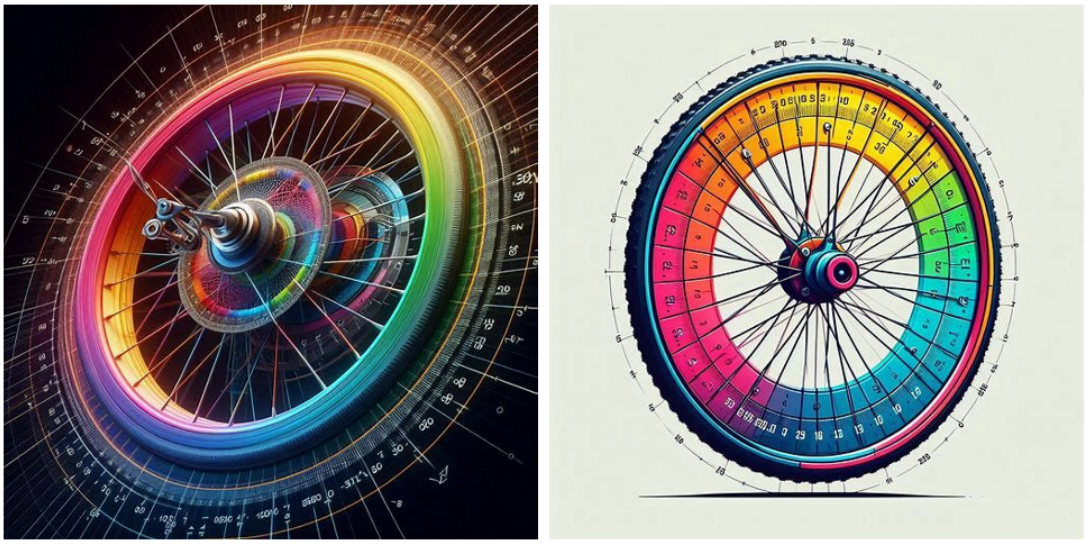


FIGURE 2. Images provided by AI for the role of radians in Wheel design

Then, to make the images more aligned with our classroom context, we asked the AI to design images featuring Iranian female students in a classroom setting (figure 3).

It should also be noted that AI provides different responses at different times because this powerful system is constantly being updated and, over time, offers newer responses. It is necessary to understand that the responses provided by AI are not always correct and may sometimes contain errors. Therefore, it is essential for teachers to critically evaluate the results, analyze the information, and carefully select what is reliable and appropriate.

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FIGURE 3. Image provided by AI featuring Iranian female students in a classroom

One of the attractive features of AI is its ability to assist teachers in creating educational content using applications and computer software. AI can precisely explain the steps for working with these tools and act as a personal tutor, to assist teachers. For instance, AI can guide us in using software like GeoGebra.

4. **Intelligent Tutoring Systems**

The footprint of AI can be found in many advanced systems and tools used in education. For instance, we can refer to Intelligent Tutoring Systems (ITS). ITS are computer-based learning tools that use AI to create adaptive learning environments for students [13, 36]. ITS software programs rely on AI capabilities to help students receive personalized education [23, 27, 28, 33, 34]. These systems analyze students' activities and provide immediate tailored feedback to meet each individual's needs. In the classroom, Intelligent Tutoring Systems facilitate tracking of students' learning processes, helping to identify their strengths and weaknesses, and ultimately providing personalized feedback. It can be concluded that employing ITS significantly enhances the quality of education by ensuring more effective and customized teaching methods [12].

An adaptive learning system, as presented by Hwang et al. [18], provides three types of instructional content for each mathematics topic: standard, detailed, and advanced instruction. The system determines the appropriate level of instruction for each student through rules based on their academic performance in the specific topic. For instance, a message might prompt the student: If the current version is advanced and you find it beyond your level, switch to the standard version.

The system designed by Hwang et al. operates as follows: The student interacts with the AI-powered educational content displayed on the system. During the learning process, factors influencing the students' learning are identified and optimized by the AI. For instance, the system measures the time

taken by the student to complete the process, and a shorter completion time may indicate greater focus. Additionally, the system monitors the student's patience. If the learning time exceeds the average, indicating potential fatigue, the system provides a notification or reminder for a break. Furthermore, if the student shows low interest or motivation, the system introduces entertaining elements, such as a joke, to encourage them to continue the process.

5. **Conclusions**

AI, as an advanced technology, provides numerous capabilities in the field of education [19], assisting teachers in teaching various educational subjects. By leveraging AI, educational data can be collected quickly and efficiently and prepared suitably for instructional use [41]. Additionally, AI serves as a valuable companion for students, helping them navigate the challenges of learning mathematics [19]. AI's ability to Connect information and summarize it into charts and mathematical symbols as the key achievements of AI's application to teaching mathematics, can effectively present facts and ideas and enhance the quality of the teaching-learning process [38]. However, while AI acts as an educational assistant, the mathematical expertise and educational guidance provided by human teachers remain indispensable. Especially the teacher-student relationship plays a crucial role in bridging the gap between students' prior knowledge and new material. It is worth mentioning that promoting a culture of proper AI use and critical thinking in the classroom is vital. Students should be encouraged to engage with AI thoughtfully and responsibly. Additionally, AI-based tools do not replace the need for human-led mathematics teaching or problem-solving [33] and over-reliance on AI for the entire teaching process should be avoided [38]. Instead, this powerful tool should be employed wisely to facilitate and enrich the quality of the teaching-learning process.

Although AI's potential in education is exciting, it is essential to recognize the challenges it introduces [26, 35]. It should be noted that AI is not infallible and may sometimes provide incorrect answers or fail to deliver the most up-to-date information [27]. Additionally, the necessity of critical thinking - encompassing comprehension, analysis, synthesis, and particularly evaluation- remains crucial when utilizing AI tools. Teachers, when dealing with AI, face a double-edged sword. On one hand, AI is an innovative tool to enhance learning, On the other hand, it hinders the development of critical thinking and analytical skills [39]. Therefore, there is a risk that students, and perhaps even teachers, may become overly reliant on AI for generating ideas and solutions, resulting in insufficient development of their creative and analytical growth and superficial engagement with educational content. To mitigate this, students must be encouraged to evaluate and verify the accuracy of the information AI provides. Guided discussions and analytical exercises in the classroom can help them critically analyze AI-generated content and build knowledge based on their refined information. Sometimes, parts of a story or example may not be tangible for students or may divert them from the intended educational goals. Therefore, the information provided by AI should be carefully selected and edited, with necessary changes or additional information added to personalize it. Ultimately, efforts should be made to ensure that AI

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never dominates situations, especially educational matters, without human supervision. Instead [35], it should function as a facilitator alongside the teacher and a companion for students to enhance the quality of the teaching-learning process.

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Narges Yaftian
Department of Mathematics, Facuty of Basic Sicence, Shahid Rajaee Teacher Training University, Tehran, Iran.
Email: yaftian@sru.ac.ir

Reyhane Niknam Oskooei
Department of Mathematics, Facuty of Basic Sicence, Shahid Rajaee Teacher Training University, Tehran, Iran.
Email: reyhaneniknam2731@gmail.com

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