INTERNATIONAL PREMIER JOURNAL OF LANGUAGES & LITERATURE (IPJLL)
VOLUME 4, ISSUE 3, 2026 p-ISSN: 3007-2336 e-ISSN: 3007-2344

ROLE OF ARTIFICIAL INTELLIGENCE IN MATHEMATICS UNDERSTANDING: OPPORTUNITIES, CHALLENGES, AND FUTURE RESEARCH DIRECTIONS

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Abstract

AI is quickly being used as an effective platform in the field of mathematics education, as it can not only generate explanations but also generate approaches to solve a problem, and engage in a discussion about math practices and techniques at length. This development presents new opportunities for enhancing practice knowledge, especially in an area where intuitive concepts and procedural habits of students are usually stable, consistent, and hard to change. Simultaneously, AI systems usually generate confident and erroneous logic, which casts doubt on the epistemic trust and overreliance, and reinforces the false beliefs. The paper concentrates on artificial intelligence as an epistemic intermediary in mathematics learning, which highlights its application in inquiry-based learning and teacher agency. Resting on the growing empirical data and theoretical methods, the paper suggests that AI can be used to develop technical solutions, as it encourages the comparison of different solution options, critical thinking, and reasoning in the context of mathematical reasoning. However, education may be hampered as AI is viewed as a professional provider of solutions, rather than exploration and thought. The article also shows the dynamic nature of the professional judgment of teachers in the AI-enhanced mathematics courses and the ethical and pedagogical boundaries of mathematics. The article ends with an overview of the main directions of further research and the importance of the educational value of artificial intelligence due to the responsible governance and careful design of pedagogical activities. The application of AI in mathematics education should be as an addition and not a replacement of human reasoning to enable learners to gain profound, enduring, and transferable mathematical knowledge.

Keywords: *Artificial Intelligence, Mathematical Practices Understanding, Mathematics Education, Inquiry-Based Learning.*

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1. Introduction

RahuThe second feature of AI-assisted inquiry in mathematics is the accessibility of interactive simulations and visuals, which can be used to explore mathematical constructs by students. The mathematical concepts are usually abstract relationships that are not easily understood by symbolic representation. Educational tools that are driven by AI can represent these concepts by means of dynamic visual environments where students can interact with variables, watch how the graph or geometric structure changes, and explore hypotheses by experimentation. These interactive experiences are quite consistent with the concepts of inquiry-based learning, since these interactive experiences enable the learners to explore patterns and relations, instead of memorizing them. AI systems assist learners in honing their hypotheses and enrich their knowledge by providing them with instant feedback on these explorations.

Inquiry-based mathematics learning can also be supported with the help of conversational AI tools. The inquiry process often presents students with situations of uncertainty, especially when they are trying to explain complex issues or support their arguments. The AI-based conversation system can imitate the conversation-based learning process, where students can ask questions and seek clarification, and explain to the system how they would approach mathematical problems differently. These discussions allow the learners to straighten their thoughts and get some guidance that helps them to keep researching instead of giving up on the problem. The interactive support is similar to the scaffolding traditionally offered by teachers or tutors, but the AI systems can offer it anytime and anywhere.

The application of AI in inquiry-based learning of mathematics also has implications for the role of teachers in the classroom. Instead of playing the main role of providing information, teachers are becoming more of facilitators to help students in their inquiry process and to interpret the knowledge produced by AI-based learning systems. AI tools are able to give the teacher specific information on the problem-solving patterns, misunderstandings, and engagement of students. Through the analysis of this information, teachers will be able to determine the areas where students need more help and develop learning activities that encourage more in-depth exploration. In that regard, AI not only contributes to the student inquiry but also helps teachers to facilitate meaningful learning experiences. Regardless of the potential advantages, reconfiguration of inquiry-based learning by means of AI also brings about critical issues and concerns. Among the issues is that students might overuse the help of AI-generated hints or explanations, and this tendency will decrease their attitudes towards fruitful struggle in solving a problem. Inquiry-based learning can be demanding in terms of persistence and reflection, and overdependence on automated assistance can hamper the acquisition of these essential cognitive abilities. Learners and teachers should be aware of how AI systems produce

feedback and recommendations, and how these systems are not as effective as they can be in deciphering mathematical reasoning. To preserve the trust and provide everyone with equal learning opportunities, it will be necessary to establish specific principles of the ethical use of AI in education.

1.3. Artificial Intelligence, Teacher Agency, and Professional Judgment in Mathematics Education

Artificial Intelligence (AI) is becoming a growing part of the educational process, especially in mathematics education, where digital technologies are becoming a part of teaching, learning, and assessment. Although most of the debate around AI in education is on its ability to improve student learning, it is also significant to examine how the technologies impact the professional role, agency, and judgment of teachers. Teachers of mathematics are at the forefront of explaining the goals of the curriculum, developing teaching plans, and facilitating the understanding of students. The introduction of AI in schools thus poses important concerns regarding how educators approach the AI systems, how their professional autonomy can be preserved, and how their teaching experience can still influence the learning of mathematics. Teacher agency is the capacity of a teacher to make decisions regarding instructional practices, instructional resources, and classroom interactions that are informed by professional knowledge and situational knowledge.

Teacher agency is especially important in mathematics education since in this area, it is frequently necessary to interpret the way student's reason, their misconceptions, and the needs of the students carefully. The use of AI technologies such as intelligent tutoring, automated assessment tools, and AI-based learning platforms is becoming increasingly able to process data on student performance and offer suggestions on instructional strategies. As much as these capabilities can be beneficial to teachers by providing them with information about learning patterns of learners, they bring in new dynamics that can affect the way teachers exercise their professional judgment. AI systems have a number of uses in helping mathematics teachers. Probably one of the most important contributions of AI is the possibility to process a great deal of learning data and to extract patterns, which might not be obvious to teachers at first sight. As an illustration, AI-based learning analytics can display widely held misunderstandings, monitor the progress of students in various subjects of mathematics, and give a detailed report on how they solve problems. Such insights can assist teachers in understanding what students need more assistance with and modify instructional strategies to align with the needs of students. In this respect, AI can be used as a rather supplementary, than a substitutive, decision-support tool, which supports the professional expertise of teachers.

Besides learning analytics, AI-based tools may help teachers to create instructional resources and tasks that facilitate learning in mathematics. AI systems can produce practice problems, propose a variety of solution strategies, and include explanations that

can demonstrate mathematical relationships. These materials can be used by teachers to enrich in-class teaching, construct differentiated learning practices, and prompt students to learn more about the mathematical concepts. The AI technologies can enable teachers to spend more time on facilitating discussion, guiding inquiry, and meeting the unique learning needs, by decreasing the time they spend performing such routine tasks as grading and problem generating (Corry M, 2026).

Nevertheless, there are also significant issues of teacher agency and professional judgment that are posed by the introduction of AI in mathematics learning. One potential challenge is that once learning institutions rely too much on AI-generated recommendations to make teaching decisions. In cases where teachers are made to accept algorithmic recommendations without critically reviewing them, they might be deprived of professional freedom. The teaching of mathematics is often associated with complicated choices that demand the recognition of context, empathy, and pedagogical sensitivity, which cannot be exactly recreated by AI systems. In such a way, AI tools should be developed and implemented in a way that can benefit teachers in their decision-making process, rather than restricting them. Professional judgment in mathematics education entails the interpretation of the thinking of the students, identifying the misconceptions, and choosing the right response in the form of instruction. These processes involve thorough knowledge of mathematical processes, techniques, and also the understanding of how students learn. Although AI systems can be used to analyze patterns in student performance data, they might not be able to fully reflect the nuances of the reasoning of students and the social and emotional aspects of learning. To illustrate, the student may be having a problem with a certain mathematical concept due to anxiety, lack of confidence, or not understanding what he or she has already learned. The teachers are in a unique position to identify these factors and act on them in a manner that would help in a cognitive and motivational approach to learning. AI systems are therefore not supposed to be considered sources of authoritative instructions but as supplements of information (Lit S., 2026).

When AI systems are interacted with teachers, it can result in more efficient and responsive learning environments in mathematics learning. Rather than regarding AI as a replacement for teachers, it would be more appropriate to envision those technologies as a colleague, which can supplement human knowledge. In this type of collaboration, AI systems perform the work with processing of information, recognition of patterns, and automatic feedback, and teachers work on understanding development, discussion facilitation, and intellectual development of students. This symbiotic association enables instructors to continue playing their major role in creating significant learning experiences in mathematics (Wang, 2026).

Moreover, teacher agency is necessary to lead students towards the responsible use of AI tools in mathematics learning. With the increase in the popularity of AI-based problem-solving platforms, there is a risk that students will use them to get solutions within a short period of time without being able to engage in the reasoning process. Educators are instrumental in setting classroom rules that promote students to learn through AI and not cheating. As part of structured learning (e.g., analyzing AI-generated solutions, finding mistakes, or analyzing alternative approaches), teachers can encourage students to master critical thinking and learn about mathematical approaches more effectively by incorporating AI tools (Mingfeng L et al. 2026).

2. Discussion

The results and the insights in this paper show the increasing role of Artificial Intelligence (AI) in determining the future of the understanding of mathematics. The AI technologies brought about a new opportunity to enhance the way students interact with mathematical concepts and practices. Even better understanding and transforming the learning of mathematics into a more interesting and engaging process through adaptive learning opportunities, intelligent tutoring, and conversation support can be achieved with the help of AI. The introduction of AI in mathematics education is a seismic shift in the standard teaching process to an information-based and more active learning.

The ability of AI systems to promote individual learning is one of the greatest opportunities that can be found in the literature. All the misconceptions are countered because AI-based applications can analyse responses of students, identify trends in their behaviour of solving problems, and provide feedback, which is personalized. This aspect assists the learner to study at his or her own pace and still get real-time instructions, which can come in handy in mathematics, where confusion in the methods of the learning process can hamper further learning. Further, AI technologies will offer the opportunity of enhancing inquiry-based learning where students are encouraged to learn different strategies of solution, pose questions, and reflect on their learning journey. These interactions help in building profound knowledge as opposed to procedural competence.

The other important implication of AI in mathematics education is that it can lead to more access to high-quality learning material. The AI-based educational systems will not only be able to support the students in the classroom environment, but also give the latter an opportunity to train their mathematical skills and master complicated ideas on their own, as well as provide a way of explaining a certain phenomenon and aiding the learning process. The AI systems may be employed as convenient auxiliary learning resources to students having little access to experienced mathematics tutors or teachers. By doing so, AI can be used to decrease education disparities and facilitate a wider involvement in mathematics studies.

Although there are bright opportunities, a number of challenges should be taken into consideration. The most prominent issues are the applicability and reliability of AI-based explanations and solutions. Although in recent years AI models have the ability to provide the correct answers to mathematical problems, they do not provide the correct or incorrect reasoning with a high level of confidence. In case students blindly follow such outputs, they can be misled and not understand a lot. Thus, the implementation of AI in mathematics education must be guided and reinstated into the course of pedagogy regarding the importance of reasoning, verification, and critical thinking. The other problem is related to the role of teachers and teacher agency. The professionalism of mathematics educators should not be substituted by AI technologies but should be enhanced with the expertise of the professionals. The teacher too has an important role in the knowledge of what the students are thinking, so that he/she can draw out a conversation and give the environment in which the students will be able to ask their questions and learn collectively. Successful implementation of AI thus needs professional growth to allow educators to learn about AI tools, assess their results, and integrate them into their teaching methods in pedagogically significant ways. Another critical discourse that emerges is that of the ethical considerations. The application of AI within the educational environment brings up the issue of information confidentiality, its disclosure, and accessibility to technology. Schools will ensure that AI will be utilized in a responsible way and that the data of students will be secured. Also, the possible biases of AI algorithms that can be obtained with feedback or learning recommendations should be commented on. Ethics and some regulatory framework will need to be put in place to ensure trust in the AI-advanced educational systems.

Further studies are necessary to explore how AI can be used in the long-term to impact the learning of mathematics, motivation, and student development. Although the initial findings indicate that AI can be a useful learning tool, further empirical studies will be needed to comprehend how the students will be able to use AI tools in the long-term, and in other learning conditions. Moreover, the possibility of the AI being programmed in a manner that encourages thought and creativity and mathematical discovery, instead of solutions, is also a question that will be answered by research.

3. Future

Further study and practice in how AI can support mathematics learning ought to take into account the requirements and roles of various stakeholders, such as learners, practitioners, teachers, and researchers. As AI technologies are advancing at a very fast pace, they will surely have an even stronger influence on math education and both opportunities and serious concerns regarding the subject, pedagogy, ethics, and approaches. Therefore, it is not only necessary to orient the future directions towards technological progress, but also the way AI could be utilized efficiently and in an

ecologically friendly manner to ensure meaningful mathematical learning. In the case of learners, AI systems of the future should be designed to develop knowledge, have critical thinking, and work with mathematical concepts as opposed to giving solutions. The design of AI tools that promote productive struggle in problem-solving is one of the key directions. The AI systems will not provide any actual solutions immediately, but will assist the learners in the reasoning process by providing them with hints, posing them with philosophical questions, and letting them experiment with the methods of doing things. Such strategies can help the students think mathematically as opposed to auto-help. Interactive visualizations, simulations, and dialogue-based explanations of abstract mathematical methods that allow easier understanding in AI-based learning platforms should also be included in future platforms. The other significant direction is the development of AI systems that could help students in determining the correctness of AI-based solutions, therefore developing the critical analysis skill and mathematical reasoning of students. In addition, AI tools will have to be flexible to various learners who have various learning styles, languages, and amounts of already acquired mathematical background.

The trends in the future, as far as the educational practitioners are concerned, e.g., the curriculum designers, the educational technology designers, should be oriented towards creating AI-enhanced learning environments, which could be reconciled with the existing theories of mathematics learning. The practitioners should make sure that AI tools are incorporated into the scheme of the curriculum in a manner that will foster inquiry-based learning, problem-solving, and critical thinking. Instead of solitary digital tools, the AI technologies will be introduced within the entire instructional ecosystems that will integrate the classroom practices, digital resources, and assessment plans. The development of transparent AI systems explaining the generation of feedback and recommendations clearly should be prioritized by practitioners as well. Openness is necessary to establish trust between teachers and learners and make sure that AI systems are not aimed at subverting pedagogical objectives. Also, practitioners should think about the ways they can create AI systems to assist with formative assessment to identify misconceptions, track learning, and provide actionable feedback to teachers.

The strengthening of teacher agency and professional judgment during mathematics teaching with the assistance of AI may be considered one of the most important spheres of the future, as far as teachers are concerned. The teachers should be at the heart of the learning process because they are those who have pedagogical knowledge and understanding of the context to direct the students. The following professional development initiatives can then be focused on ensuring that teachers become AI literate to understand how AI systems work, how they can critically evaluate what they generate, and how they can fit them into the purposeful classroom process. The co-design and

evaluation of AI-based educational tools should also involve teachers to make sure that the technologies are based on the genuine needs in the classroom. The second possible prospect is that AI can help teachers in doing some of the routine tasks, such as grading, feedback, and progress monitoring, and, thus, teachers will be in a position to devote more of their time to facilitating conversations, inquiry, and addressing the issues of the students. The responsible use of AI technologies should also be taught by the teachers and used as a way of facilitating the learning process, but not to substitute independent thinking.

Researchers should fill in some of the gaps in the existing body of literature on AI in mathematics education in the future. To begin with, more empirical research is required to investigate the long-term effects of AI-assisted learning on the understanding, problem-solving capacity, and attitude towards mathematics in students. Although the initial research is positive, the evidence on the long-term impact of continual exposure to AI tools on cognitive development in learners is still scarce. Second, researchers ought to pursue the use of AI to assist mathematical activities like reasoning, argumenting, and modeling, in addition to targeting the accuracy of computations. Third, computer scientists, cognitive psychologists, and data scientists will need to collaborate with mathematical educators to come up with AI systems that are coordinated with the technological capacities and learning values. The other important field of future study relates to considering the ethical and social consequences of AI in math education. All the problems of data privacy, algorithmic bias, transparency, fair access, etc., will be considered fully to ensure that all learners can enjoy AI technologies. The scholars are encouraged to explore the potential of AI systems to unwittingly perpetuate current disparities and how to create inclusive technologies to work in various educational settings. Research on the role of AI that should be applied in responsible assessment practices also needs to be conducted to ensure that the automated assessment would be more sufficient in terms of knowledge of students and would not affect a certain group of students negatively.

To sum up, the development of AI in mathematics learning needs to be moderated to take into account technological innovation, pedagogical integrity, and ethical responsibility. By listening to the requirements of learners, contributing to the creation of knowledge in teachers, becoming a leader in the work of practitioners, and promoting high-level research, AI can contribute to the further evolution of mathematics education. As a means of knowledge expansion in a prudent approach, AI may be adopted to enlarge the knowledge base, deepen the knowledge, and offer educational interactions that can lead to the emergence of curiosity, imagination, and critical thinking in mathematics.

4. Conclusion

The quickly developing concept of Artificial Intelligence (AI) is changing the concept of mathematics education as it presents new tools that can assist learners throughout the learning process, problem-solving skills, and personalized learning. This

paper has discussed the opportunities and challenges of AI in mathematics understanding and the future research directions. Adaptive learning systems, automated feedback systems, and data-driven analytics are AI-driven technologies that have been used in the context of learning intelligent tutoring systems, which have demonstrated a titanic ability to assist students in developing a deeper conception of mathematics. These systems will be able to locate all the learning gaps and offer one-step instructions and approach teaching materials based on the students' capabilities and learning rate. Consequently, AI has the potential to encourage student learning, lessen the learning obstacles, and assist teachers in providing more efficient mathematics teaching.

Although these opportunities are promising, a number of concerns have to be resolved in order to make sure that AI in mathematics education has been successfully integrated. Problems of information confidentiality, the bias behind algorithms, ethical use of AI systems, and overreliance on automated tools remain of concern. Additionally, the lack of access to new technologies (particularly in the developing world) may be yet another source of the digital divide among learners. Mentoring should also be done to train teachers so that they can be in a position to utilize AI tools in teaching. There are no relevant institutional and professional development options in place to realize the benefits of AI in the classrooms in full.

In conclusion, AI can revolutionize the aspect of mathematics education and make it more personal, interactive, and approachable. However, its issues must be discussed in somewhat more detail, and more studies must be conducted to ensure that AI technologies can be utilized to deliver equitable, meaningful, and effective mathematics instruction to every student.

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