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# THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN MATHEMATICS EDUCATION: A SYSTEMATIC LITERATURE REVIEW

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**Abstract**
The rapid advancement of technology in the Beta generation era continually presents new developments. To keep pace, the world of education must adapt accordingly. The alignment of technological progress with the utilization of artificial intelligence (AI) in education is expected to yield positive impacts. This research aims to analyze the utilization of AI technology implemented in mathematics learning. Employing a qualitative approach with a systematic literature review method, the study draws its literature from Google Scholar, focusing on publications from the last five years (2020 – 2025). The Publish or Perish application was used by the researchers to analyze and manage scientific references. The findings indicate that the utilization of AI can assist students in comprehending concepts and optimizing classroom learning.

**Keywords:** artificial intelligence, education, mathematics

## Introduction

Current technological advances are developing at a rapid pace. Therefore, the world of education must adapt to these advances so as not to fall behind the times. This adjustment is urgently needed for the development of education, especially mathematics education. In teaching mathematics, technological advances can be utilized to make it easier for students to understand this abstract subject, one of which is through artificial intelligence. This development is driven by the finding that educational technology in general expands learning opportunities and enables various access paths to mathematical material through a blended learning approach and personalized learning differentiation (Attard & Holmes, 2020). In the framework, AI can be interpreted as part of a technology ecosystem that provides visualization, dynamic manipulation of mathematical concepts, and alternative and more diverse feedback compared to traditional approaches (Attard & Holmes, 2020). Consequently, the argument for adapting education rests on a robust evidence base indicating that technology-enabled strategies can enhance mathematical reasoning, spatial ability, and problem-solving capabilities across diverse learner populations.

The use of AI can not only help students visualize abstract mathematical concepts into tangible concepts, but it can also strengthen students' basic understanding of mathematical material. AI technology can also be used as a learning aid that considers students' learning styles. Working in the fields of

mathematics, which emphasizes the use of digital technology, shows how tools for visualizing and manipulating mathematical concepts dynamically can accommodate variations in students' learning outcomes. Moreover, AI can serve as a complement that strengthens instruments for personalization, for example, through task recommendations, difficulty level adaptation, and feedback tailored to student responses (Attard & Holmes, 2020; Ross et al., 2025). In parallel, research on data modelling and meta-representational practices demonstrates that when students generate and critique multiple representations, they develop more sophisticated statistical thinking and reasoning about data. The emergence of construct maps and related diagnostic frameworks-contexts in which AI could facilitate real-time mapping of student thinking-further supports the view that AI-enabled visualization can scaffold mathematical understanding by making reasoning visible and actionable. Taken together, these strands suggest that strengthening foundational understanding through guided exploration of representations and their relationships.

### *Study Purpose and Research Question*

This study aims to examine and synthesize empirical evidence on the use of artificial intelligence in mathematics education. This study also aims to gain an in-depth understanding of how artificial intelligence can help students understand abstract mathematical concepts and the use of artificial intelligence in the teaching and learning process of mathematics. The findings obtained from this study can be used as a basis for an investigation into mathematics learning methods that utilize artificial intelligence. Furthermore, the findings from this study also answer the research question: How can the use of technology in mathematics learning help students understand mathematical concepts?

## Method

### *Search Strategy*

This study utilizes keywords in searching for data sources to answer the research questions. The following keywords were used in the search:

1. Artificial intelligence, including "technology", "ChatGPT", and" AI."
2. Mathematics education, including "mathematics", "learning", "mathematics learning", "education", "mathematics education".

The use of these keywords resulted in 356 articles, which were searched using Publish or Perish software from the following databases: Springer, Elsevier, Taylor & Francis, SAGE Journal, ERIC, and JSTOR. However, only 2 articles met the exclusion and inclusion criteria for in-depth review.

### *Analysis Strategy*

The three articles were analyzed based on the following factors.

1. Publication year between 2020 and 2025
2. Ranked in Scopus (Q1, Q2, and Q3)
3. Research objectives

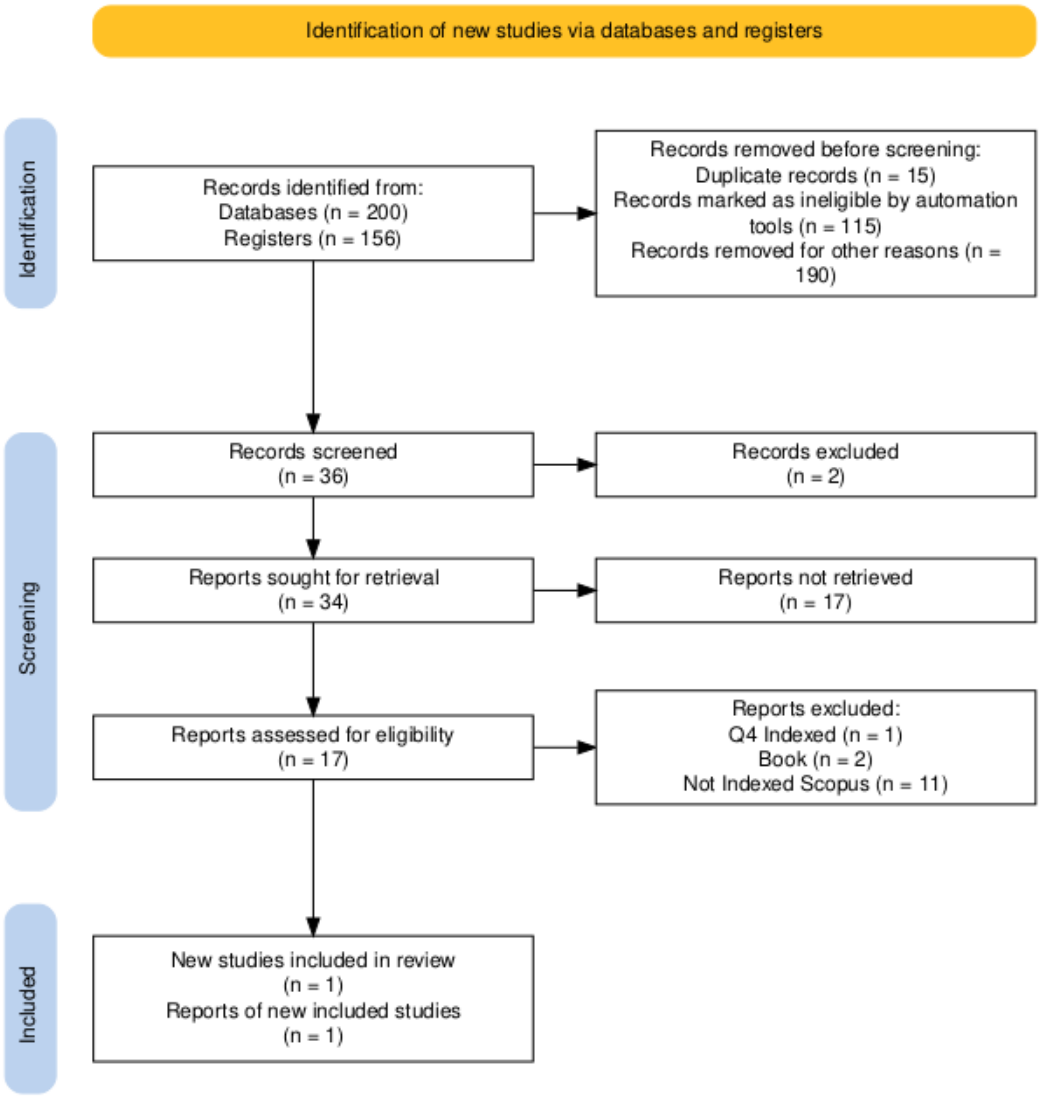


Figure 1. PRISMA Flow Chart (Haddaway et al., 2022)

### *Data Coding and Analysis*

There were two steps in conducting the research. The first one was creating a table to classify the articles obtained for analysis. Then, the second step was synthesizing data based on the three factors contained in the analysis strategy.

## Findings and Discussion

This review presents the synthesized results of research on the use of artificial intelligence in mathematics education, which covers the use of artificial intelligence in teaching and learning activities and the use of artificial intelligence as a learning medium. Research conducted by Opesemowo et al. (2024) entitled "Artificial intelligence in mathematics education: The good, the bad, and the ugly" states that integration of artificial intelligence in mathematics education offers promising advances as well as potential obstacles.

### *Artificial Intelligence's Potential for Learning Mathematics*

The use of artificial intelligence has the potential to enhance the experience of learning mathematics, namely:

*For students*

Artificial intelligence-assisted learning can help students, among other things, to identify individual needs, learning styles, and performance through the analysis of artificial intelligence algorithms. Not only that, but AI technologies, such as virtual simulations and gamification, can create an engaging learning environment. Thus, these tools can encourage students to be more active and practice problem-solving and critical thinking skills, making mathematics feel easier and more enjoyable. There are Augmented Reality applications that can make mathematical concepts more real by displaying digital information in the real world. Recent findings show that increased access to mathematical content through digital connectivity is now part of broader teaching practices, with teachers' digital practices influencing how students experience mathematics learning (Attard & Holmes, 2020). The context of how AI can help identify individual student needs, particularly in relation to cognitive and language abilities, also has a strong empirical foundation. For example, research on the role of language in mathematical problem-solving shows that reading ability and language resources are highly relevant to success in solving word problems and mathematics learning in general, implying that AI systems assessing student responses need to consider language load and include appropriate linguistic support (Reinhold et al., 2020).

*For teachers*

In addition to its benefits in developing students' abilities, artificial intelligence also has a positive impact on teachers. Artificial intelligence can automatically correct math assignments and exams, saving teachers time so they can focus on other aspects of teaching. This assistance makes teachers faster, more efficient, and more accurate in their assessments. Furthermore, artificial intelligence can assist mathematics teachers by providing personalized training, modules, and learning resources tailored to their needs, based on performance analysis and areas that need improvement. Personalized learning modules can be developed by AI with reference to evidence of effective practices in mathematics professional development, such as developing mathematical thinking skills through multiple representation tasks and diverse task interactions. One of the main pillars of AI in teacher professional development is its ability to build teacher learning profiles based on current knowledge and beliefs, so that training can be personalized to address their specific needs. Thus, AI that analyses teachers' perceptions and realities of practice can train pathways that enhance content competence while mitigating attitudinal barriers to practice change.

### *Challenges and Limitations*

While artificial intelligence may have a significant impact on mathematics education, it has several challenges and limitations, these are:

*For students*

The use of artificial intelligence has several drawbacks, including a lack of creativity and problem-solving skills. Although AI is increasingly deployed as a pedagogical aid, a considerable body of research in mathematics education emphasizes that meaningful creativity and robust problem-solving emerge from carefully designed learning environments, contexts, representations, and curricular structures that support inquiry, ambiguity, and authentic practice, and an inability to explain thought processes. An excessive focus on computational skills, a lack of emotional intelligence, a loss of critical thinking skills, and a dependence on artificial intelligence for problem-solving also cause limitations. The main emphasis is that human problem-solving behavior is influenced by a spectrum of cognitive, affective, and social agency abilities. Reliance on AI for computational tasks can reduce opportunities for developing these capabilities (Reinhold et al., 2020). Creative power, agency, and collaboration in mathematical problem-solving are also important focuses. The dynamics of agency among learners when solving problems, where one agent may lead the conversation with mathematically meaningful arguments, while other agents tend to listen without developing further mathematical arguments, so that collaboration often does not reach a level of mutually challenging discussion or produce new understanding (Hansen, 2022). Reliance on AI to automatically perform representation and representation conversation processes can reduce opportunities for earners to actively construct their own mental representations, which in turn can affect the improvement of critical thinking skills and the formation of adaptive problem-solving strategies. Therefore, AI for mathematics learning should be designed to facilitate, rather than replace, the representational exploration and thinking tools that students need to develop modelling and quantitative reasoning skills.

*For Teacher*

In teaching, teachers must follow the applicable curriculum. When using artificial intelligence, teachers only follow learning paths that have been determined by data and algorithms. If there are changes to the curriculum, the content presented will not be in line with the latest requirements. Modern mathematics learning places teachers as the main link between the applicable curriculum and classroom learning practices. This role becomes more complex when artificial intelligence (AI)-based devices or data-based learning technologies are involved, because the learning paths presented are often regulated by data and algorithms working behind the scenes (Attard & Holmes, 2020). The curriculum, as a normative framework governed by education policy, is revised periodically to reflect expected competency requirements and relevant scientific trends. When curriculum changes occur, the content AI presented risks of being out of sync if the content update mechanism is not directly integrated with the curriculum update process. Therefore, the literature suggests that although AI and technology can offer more dynamic solutions, the role of teachers remains central in interpreting, aligning, and assessing the suitability of materials to new national and local standards. In practical terms, a framework is needed that integrates AI with curriculum through evidence-based learning design, continuous professional learning, and cross-stakeholder collaboration in schools.

Another study discussing the use of artificial intelligence in mathematics, entitled ChatGPT: A revolutionary tool for teachers and learning mathematics

(Wardat et al., 2023), found that the use of ChatGPT can improve mathematical ability. Not only that, but this message-based application also provides users with basic knowledge about mathematics and various other topics. This is confirmed in research that highlights that the use of technology can expand opportunities for learning mathematics through different access channels and through dynamic concept visualization, as well as providing more flexible feedback and communication between teachers and students (Attard & Holmes, 2020). These findings are consistent with other studies that emphasize the role of engagement, motivation, and learning context as key mediators between technology and mathematical achievement (Skilling et al., 2020). Thus, it provides a theoretical basis for the assumption that AI conversation tools can replicate the benefits of technology-based learning, provided that the instructional design and implementation context consider the principles of effective learning (Attard & Holmes, 2020; Skilling et al., 2020). Furthermore, this literature emphasizes that planned learning practices-including the design of deliberate practice, exercise variation, and carefully managed cognitive load-can promote more enduring mathematical knowledge formation and more effective problem-solving abilities. In solving mathematical problems, ChatGPT has a capable capacity with the use of artificial intelligence algorithms and machine learning, so that it can present solution steps to its users. The results of its answers are represented in text or visual formats, making it easy for users to understand the problems and their solutions. One of these pillars is the use of spatial and graphical representations as reasoning aids, given that spatial visualization skills may contribute significantly to problem-solving that utilizes geometric shapes or visual patterns. At the same time, the ability to translate real-world situations into quantitative models—which involves interpreting quantities, relationships between variables, and representations through various forms—is shown to be strongly linked to modelling capacity and quantitative understanding in students and prospective educators. Therefore, interaction designs that combine the elaboration of representations (text, diagrams, tables) with conceptual modelling steps can enhance the quality of AI assistance in solving mathematical problems (Hansen, 2022).

Despite its advantages, ChatGPT also has limitations. One of them is the potential for bias caused by users. In the context of mathematics learning and reasoning practices, educational literature shows that bias can arise when only one representation is used, or when language and argument structure are inadequate to reveal the actual cause and effect. Furthermore, studies on how mathematical activities are learned and interpreted through the modelling process show how the phases of modelling and the choice of objects and semiotic signs can limit or shape the user's interpretation. Efforts to understand the interaction between users and models can also be explained through studies that emphasize the importance of how variation, symbolism, and argumentative proof guide students' understanding and how bias can arise if the context is not presented comprehensively. Therefore, this study attempts to integrate these findings to explain how user-generated bias can occur in the dynamics of interaction with ChatGPT, and how educational practices based on dual representation, argument structure, and modelling approaches can inform strategies to mitigate such bias. In general, this framework positions bias as a phenomenon that arises at the intersection of context, language, representation, and users' epistemic practices, rather than simply an attribute of the model. With

this foundation, we can discuss how users can inadvertently shape model outputs through how they structure requests, the language used, and the conceptual frameworks brought to life in dialogue. The continuation of this argument stems from the idea that representation, argumentation, and modelling are social practices that shape understanding, so bias needs to be analyzed through these lenses to formulate more appropriate intervention strategies. This also provides space to develop training practices and prompt designs that encourage users to activate various representations and construct more structured arguments.

In summary, this discussion links potential user bias to three key pillars in the education literature: multiple representations, argumentation frameworks, and semiotic modelling dynamics, which can then be used as a basis for designing interfaces that are more resilient to bias. Such a review is important because if bias is not recognized or properly unpacked, the resulting responses may reinforce user misinterpretations rather than reflecting correct knowledge. Thus, the purpose of this analysis is to formulate how the strengths and limitations of representation and the structure of argumentation and modelling play a role in the formation of user bias in the context of interactions with ChatGPT, and to offer strategies based on the educational literature to reduce this bias.

## Conclusion

Based on the results of the literature review, it was found that the benefits of using artificial intelligence can help students understand difficult mathematical concepts by presenting answers in text and visual form. In addition, artificial intelligence can also help teachers improve their knowledge through personalized training. Despite all the advantages of artificial intelligence, this man-made application also has several limitations. One of them is the potential for bias caused by its users. This cannot reveal the actual cause and effect. Therefore, users need to consider whether the answers generated by this application are correct or still need improvement.

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