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REVIEW ARTICLE
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Mapping the landscape of Artificial Intelligence in Mathematics Education: A systematic Review

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ABSTRACT

This systematic literature review investigates the landscape of Artificial Intelligence (AI) in mathematics education, emphasizing successful implementation models, positive learning outcomes, and key factors influencing effective adoption. Through a synthesis of recent empirical studies, the review identifies innovative applications of AI, including personalized tutoring platforms, AI-powered chatbots in e-textbooks, and adaptive learning systems designed for exam preparation. While acknowledging ethical challenges, such as potential biases and limitations in assessment capabilities, this research highlights Capacity of AI to enhance student engagement, foster deeper understanding of concepts, improve test preparedness, and offer more accessible learning experiences. The review also explores key pedagogical considerations and the importance of teacher collaboration, demonstrating that AI can be most effective when integrated into a framework that promotes ethical and equitable access. In alignment with the National Education Policy (NEP) 2020, this review advocates for a proactive approach that prioritizes teacher training, evidence-based practices, and technology implementation that strengthens existing pedagogies. Recommendations are provided for educators, policymakers, and researchers, underscoring the need for a collaborative ecosystem that leverages AI to transform mathematics education to meet the needs of all students while adhering to the pillars of the NEP 2020 and preparing learners for future challenges.

Keywords: *Artificial Intelligence (AI), Mathematical Education, Technology in Education, Systematic Literature Review(SLR), Artificial intelligent tools*

Introduction

The integration of technology in education has reached a transformative stage with the emerge of Artificial Intelligence (AI), fundamentally altering the landscape of teaching and learning (Ilic et al., 2024; Weigand et al., 2024). Within mathematics education, this shift is particularly significant, offering opportunities to personalize learning, automate assessments, and develop intelligent tutoring systems. This systematic review aims to map this evolving landscape of AI in mathematics, synthesizing recent research to understand current applications, effectiveness, and inherent challenges.

Recent years have witnessed a surge in the development and implementation of AI tools for mathematics education. These applications span a range of functionalities, from AI chatbots like ChatGPT, explored for their capacity to provide personalized tutoring and assist with mathematical problem-solving (Almarashdi et al., 2024; Ergene & Ergene, 2024; Jančařík et al., 2023; Ramprakash et al., 2024), to AI-powered platforms that adapt to student learning and offer automated feedback (Slobodsky et al., 2024). Furthermore, the potential of AI in assessing mathematical understanding is being researched through its application in evaluating student responses to open-ended problems (Lee et al., 2024), mathematical modeling tasks (Spreitzer et al., 2024), and analyzing hand-drawn solutions. These advancements, while promising, demand critical evaluation of their effectiveness, limitations, and impact on equitable access (Moral-Sánchez et al., 2023).

While previous systematic reviews have begun to explore AI in education (Opesemowo & Adewuyi, 2024; Panqueban & Huincahue, 2024), these often encompass a broader scope. A focused synthesis of research specific to mathematics education is needed, focusing it’s unique pedagogical requirements. Moreover, integrating AI raises ethical and practical considerations, including the potential for bias, equity issues, and the need for effective pedagogical strategies (Källberg & Roos, 2025). It is, therefore, vital to understand how AI is being integrated, the views of stockholders on its impacts, and to address the challenges posed by its adoption.

This systematic review goes beyond simply describing the landscape of AI in mathematics education; it seeks to understand the implications of these technological changes within the mathematics classroom. Through analysis of existing research, we address the following questions, guided by the understanding that sound pedagogy must remain paramount in all technological integration (Ilic et al., 2024).

Research Questions

1. What innovative strategies and approaches are being employed to integrate AI into mathematics education, as evidenced by case studies and empirical research?
2. What are the reported positive impacts of AI-enhanced mathematics instruction on student learning outcomes as demonstrated in the selected studies?
3. What key factors contribute to the successful implementation of AI in mathematics education?

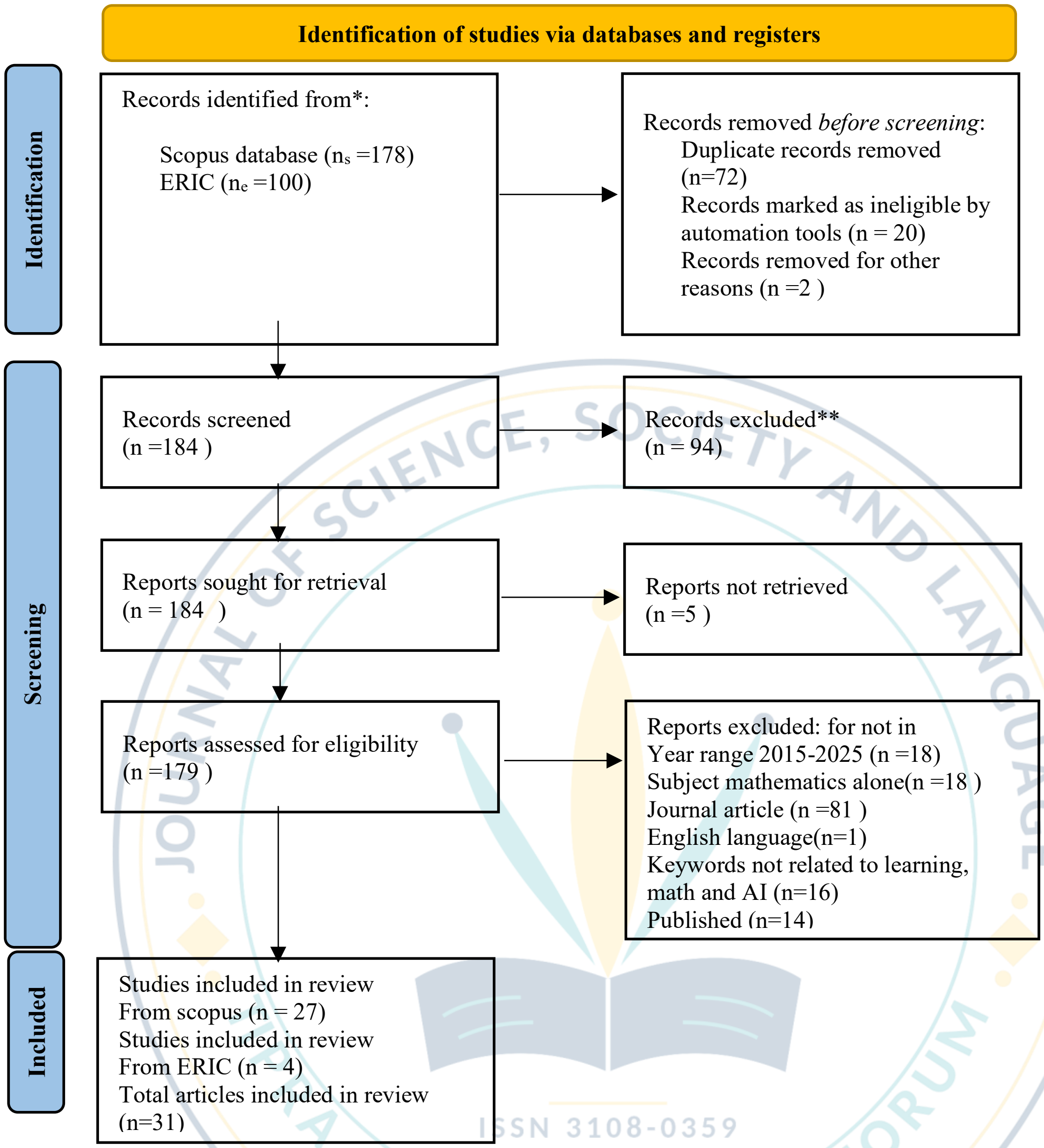
4. What are the main challenges, limitations, and ethical considerations associated with the integration of AI in mathematics education?

This systematic review provides a critical analysis of recent research, aiming to inform educators, researchers, and policymakers on the implications of AI in mathematics education. It will map the current landscape and serve as a foundation for future investigation and development.

Theoretical framework

This systematic review adopts a theoretical framework grounded in three interconnected perspectives: Situated Cognition, TPACK (Technological, Pedagogical, and Content Knowledge), and Critical Theory. The Situated Cognition perspective acknowledges that learning is intrinsically linked to activity, context, and culture (Brown et al., 1989; Lave & Wenger, 2009), shifting the focus from AI tools as mere replacements for instruction to mediators of specific mathematical practices and communities. This lens helps analyze how AI shapes student engagement, problem-solving, and understanding within defined learning environments, informing our examination of AI applications (RQ1), stakeholder perceptions (RQ2), and assessment validity (RQ3). Complementing this, the TPACK framework (Mishra & Koehler, 2006) emphasizes the interplay between technological, pedagogical, and content knowledge, highlighting the evolving roles of teachers, the need for effective pedagogical strategies, and the importance of well-designed curricula that leverage strengths of AI. By considering TPACK, we can explore the pedagogical considerations for integrating AI (RQ4), the skills and knowledge teachers require (RQ2), and how AI can enhance rather than replace existing teaching practices (RQ4). Through the integration of Situated Cognition, TPACK, this review seeks to provide a nuanced and comprehensive understanding of the complex landscape of AI in mathematics education, enabling a robust and insightful analysis of the existing research.

Figure 1:PRISMA flow diagram



Source: Page et al., (2021). BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

The initial search for literature was performed in the Scopus database. Scopus was chosen as it is a large, reputable, and respected index of published work in academic fields. We started with the search string, as follows:

("artificial intelligence" OR "AI") AND ("mathematics education" OR "math* education" OR "teaching mathematics" OR "learning mathematics") AND ("applications" OR "impacts" OR "tools" OR "frameworks" OR "strategies" OR "systematic review")

This search string was crafted to capture a broad range of articles related to AI in mathematics education, focusing on applications, impacts, tools, frameworks, strategies, and existing systematic reviews.

The initial search in Scopus resulted in a total of 4316 articles. To ensure the relevance and quality of the identified literature, several filters were subsequently applied. The first filter was a date range, which reduced the results to 4136 articles. The results were then limited based on subject area, which eliminated the results from computer science, social science and general mathematics, resulting in 2452 articles. The results were further refined by limiting document type to articles and conference papers which resulted in 1378 articles. By eliminating the articles which are in press and conference papers which are not finalised resulted 1256. Further limiting to English language articles there were 1219 articles. Excluding keywords such as Engineering education, Engineering, Entrepreneurship, banking other miscellaneous keywords resulted 661 articles.

With that prompt it was 4316 documents
2014-2025 it is 4136 documents
Limit to social, math, art and humanities, psychology it is 2452 articles
Limit to articles 1378
Final stage 1256
English 1219
Open access 697 or 477
Excluding engineering educatin, engineering, enterpurner ship 661
TITLE-ABS-KEY ("artificial intelligence" OR "AI") AND ("mathematics education" OR "math* education" OR "teaching mathematics" OR "learning mathematics") AND ("applications" OR "impacts" OR "tools" OR "frameworks" OR "strategies" OR "systematic review") AND PUBYEAR > 2004 AND PUBYEAR < 2026 AND PUBYEAR > 2013 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "MATH") OR LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "ARTS")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")) AND (EXCLUDE (EXACTKEYWORD , "Engineering Education") OR EXCLUDE (EXACTKEYWORD , "Engineering") OR EXCLUDE (EXACTKEYWORD , "Entrepreneurship"))

Inclusion	Exclusion
Focused on mathematics education, Mathematics (Subject specific) science education where maths is a integral part.	Non math subjects (eg: only mention of arts, machine learning, computer, vocational subject, tourism and hospitality, earth science, purely science,
Sample is sticking strictly to the school students	Other than school students eg: university students, teacher education
Strategies which are focused in mathematics learning only	Strategies and other which are not focused on maths eg: disease diagonosis,
Studies which are focused on positive impact	Studies which are not focused on mathematics

on mathematics learning.	leanring eg: enivornmet protection
Studies involving the skills of mathematics	Studies whichare not involved on the skills of mathematics eg: language learning, psychological behaviours,
Included studies which focused on mathematics achievement and achivement data. Eg: PISA	Studies which are not involved on the matheamtics.

Methodology of the systematic literature review

Research Design

This systematic literature review (SLR) was conducted to explore the landscape of AI in mathematics education, focusing on innovative strategies, success stories, and impactful case studies, ultimately addressing the research questions set forth. Following a structured and transparent approach, this study employed a rigorous methodology to synthesize relevant publications, drawing inspiration from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). This methodology allowed for an accurate and reproducible search for high-quality evidence in the field. We will be using PRISMA to ensure a strong and effective search. The methodology section is based on the following core steps: identification, screening, eligibility, and inclusion, as detailed in the subsequent sub-sections.

Table 1: Search strings for different data bases

Database	Search String
Scopus	*("artificial intelligence" OR "AI") AND ("mathematics education" OR "math* education" OR "teaching mathematics" OR "learning mathematics") AND ("applications" OR "impacts" OR "tools" OR "frameworks" OR "strategies" OR "systematic review")*
ERIC	*("artificial intelligence" OR "AI") AND ("mathematics education" OR "math* education"*

	OR "teaching mathematics" OR "learning mathematics") AND ("applications" OR "impacts" OR "tools" OR "frameworks" OR "strategies" OR "systematic review")

Table 2: Criteria for Inclusion and Exclusion of documents

Criteria for Inclusion	Criteria for Exclusion
Year of publication 2015-2025	<2015
Indexed journal	Non-indexed review journals, book chapters, dissertation, opinion, reviews and prefaces.
Language of English	Non-English
Mathematics education and articles related to mathematics application	Articles related to medical, engineering, health, environmental.
Final Published	All the preprints and under processed articles

Systematic Review Process

Identification

The initial search for literature was performed in the Scopus and ERIC databases. Scopus was chosen as it is a large, reputable, and respected index of published work in academic fields. ERIC was added as an additional resource. We started with the search string, as follows:
("artificial intelligence" OR "AI") AND ("mathematics education" OR "math* education" OR "teaching mathematics" OR "learning mathematics") AND ("applications" OR "impacts" OR "tools" OR "frameworks" OR "strategies" OR "systematic review")
This search string was crafted to capture a broad range of articles related to AI in mathematics education, focusing on applications, impacts, tools, frameworks, strategies, and existing systematic reviews.
The initial search in Scopus resulted in a total of 178 articles. To ensure the relevance and quality of the identified literature, several filters were subsequently applied. The first filter was a date

range, which reduced the results to 160 articles. The results were then limited based on subject area, which eliminated the results from computer science, social science and general mathematics, resulting in 142 articles. The results were further refined by limiting document type to articles and conference papers which resulted in 117 articles. By limiting results to English language articles there were 116 articles. Keywords such as artificial intelligence, students, mathematics education, mathematics, education, learning mathematics, Math Education, Mathematical problems, Mathematical concepts, learning tool, learning experiences were then applied resulting in 100 articles. Results were further narrowed when limiting the source type to journal and conference proceedings resulting in 46 results. The final published stage reduced it to 41 articles, and selecting open access, resulted in 32 articles. These results were further reviewed for inclusion in the analysis. This process resulted in a total of 32 open access articles from Scopus to be considered for the next phase of the review process.

A secondary search was performed on the ERIC database, which resulted in 28 potential articles. These articles were also limited to journal articles, English language, and the key search terms which resulted in 6 articles. Of these articles, 2 were removed due to duplicates. This resulted in 4 final articles from ERIC, to be considered with the 32 from Scopus.

Screening

Following the identification phase, the 32 articles from Scopus and 4 from ERIC, (a total of 36 articles) were subject to careful screening. This phase included a review of the abstracts and titles to identify literature that did not fit the scope of this review. A thorough review of the 32 abstracts from Scopus led to a reduction to 13 articles, and a review of the abstracts from ERIC led to all 4 being included, after 2 duplicates were removed.

Eligibility

After the screening phase, a full review was conducted of all 17 articles. Title of each article, abstract, methodology, results, and discussion were reviewed to confirm they aligned with the scope of this study which is on successful models of implementing AI in mathematics education. This involved verifying that each article had information relevant to AI integration in math education, as well as a robust analysis that helped to explain and define the findings. This final review process resulted in the final set of articles for the study.

Inclusion and Exclusion Criteria: To ensure consistency and rigor in the article selection process, specific inclusion and exclusion criteria were defined.

Criteria for Inclusion

- Studies that were published between 2015 and 2025.
- Studies that focused on applications of AI in mathematics education.
- Studies that focused on the impact and strategies on AI in the math classroom
- Journal and conference proceedings publications
- Studies with clear methodology, results, and discussion sections.
- Open access articles
- Studies written in the English language.

Criteria for Exclusion

- Studies that did not focus on AI in mathematics education.
- Studies focusing only on theory rather than practical applications.
- Studies that lacked clear methodology or results.
- Non-open access articles
- Studies that were not journal or conference proceedings.

Through this structured and systematic process, this review identified the final set of articles that would be used in this research. The figure below visually represents the flow of articles through each stage of the systematic review process based on the PRISMA guideline, with the initial 178 articles from Scopus reduced to 27, and the 28 initial articles from ERIC reduced to 4, resulting in 31 articles for the review. The systematic approach allowed us to analyze key and effective models for integrating AI into the mathematics classroom, while also allowing us to determine the future goals for researchers and educators in this area.

Study Findings

A total of 31 AI studies have been analyzed, published from 2015 to 2025. This part addresses the subsequent research inquiries.

1. What innovative strategies and approaches are being employed to integrate AI into mathematics education, as evidenced by case studies and empirical research?
2. What are the reported positive impacts of AI-enhanced mathematics instruction on student learning outcomes as demonstrated in the selected studies?
3. What key factors contribute to the successful implementation of AI in mathematics education?

4. What are the main challenges, limitations, and ethical considerations associated with the integration of AI in mathematics education?

Table 3: Different AI approaches adopted in the mathematics classroom

Our analysis of the selected studies, focused on understanding innovative AI integration strategies (Research Question 1), revealed a varied range of approaches being employed in mathematics education. As shown in Table 1, the most common approach identified was the use of AI-powered tutors (with a frequency of 2), as seen in the studies by Alvarez (2024), and (Jančařík et al., 2023) which focuses on the specific use of AI-driven software. Following this, AI chatbots in Interactive e-textbooks are explored (with a frequency of 1) in the work by Ergene & Ergene (2024), which highlights the implementation of AI within digital learning tools. AI Chatbots for tutoring also were studied, with Jančařík et al. (2023) finding that chatbots could be used in classrooms. Additionally, AI-Enhanced Exam Preparation Platforms, were found to be a helpful tool (Slobodsky et al., 2024), as well as an AI Integrated calculus teaching method was used to update teaching (Torres-Peña et al., 2024). Other less implemented approaches were the use of AI for Automating Feedback on classrooms (Suresh, 2022), and exploring the possibilities of AI for mathematics learning (Stefanova & Georgiev, 2024). Teachable agent systems were used as teaching tools for mathematics (Song, 2017), and lastly using AI to Evaluate vision language models with hand-drawn mathematics (Baral et al., n.d.). These various approaches align with and inform the use of Situated Cognition, which sees knowledge situated in activity and context and how these are being tested in real world implementation. These findings show how AI is being used in a range of different ways, each with a specific focus, and also highlights the specific framework for the implementation in real world settings.

Key reported positive impact areas mathematics education

Table 4: Key reported positive impacted areas in the mathematics education

Reported Impact Area	Reviews
Enhanced Calculus Learning	Alvarez, 2024
Increased Learning Satisfaction	Moral-Sánchez et al., 2023
Improved Exam Preparation	Slobodsky et al., 2024
Improved Teacher Discourse, leading to enhanced learning	Suresh, 2022

Table 4 summarizes the positive impacts of AI-enhanced mathematics instruction on student learning outcomes, addressing Research Question 2. The most highlighted impact is the use of the tools to improve test scores and learning of calculus (Alvarez, 2024) with a frequency of 1. This study highlights the practical application of AI in the classroom setting. In addition to the focus on improved test scores, increased learning satisfaction was also found (Moral-Sánchez et al., 2023), as well as improved exam preparation strategies for students (Slobodsky et al., 2024). Lastly it was also found that the automated systems can help to better teacher discourse and increase student learning (Suresh, 2022). These positive impacts align with TPACK, as it highlights the importance of understanding pedagogy, content and how they integrate with technological tools.

Moreover, the framework highlights that learning is active and constructivist, and should build upon prior knowledge, which are important factors that need to be incorporated when new technological tools are integrated into the classroom setting. By understanding these positive impacts, educators can see how technology can improve student engagement, satisfaction, and scores.

Factors to be considered for the successful implementation of the AI in the Mathematics education

Table 5: Key Factors for Successful AI Implementation and Related Frameworks & Reviews

Key Factor for Successful Implementation	Reviews
Ethical Considerations & Implementation	Almarashdi et al., 2024
Affordances of AI Tools	Ergene & Ergene, 2024
Effective Integration Strategies	Stefanova & Georgiev, 2024
Adapting instruction using AI	Torres-Peña et al., 2024

Table 3 lists the key factors that contribute to the successful implementation of AI in mathematics education, aligned with Research Question 3. Based on the studies reviewed, one of the most important factors is to have ethical implementations. (Almarashdi et al., 2024). These factors also take into account the affordances of the AI tools to work effectively (Ergene et al., 2024), which helps educators and learners understand how they can effectively use the new technology to benefit themselves. Effective Integration Strategies also help to increase success in

AI implementation (Stefanova & Georgiev, 2024). Lastly, and most importantly, it is crucial to be able to adapt to this new way of learning and update teaching with AI (Torres-Pena et al, 2024).

This information can be best understood by TPACK which takes into consideration the importance of content, pedagogy and technology and how they can effectively be integrated to improve the lives of students. Further, it is relevant to situate this within the context of innovation diffusion theory, which highlights how different factors can influence the adoption rate of technology.

Main challenges, limitations, and ethical considerations associated while integrated AI in mathematical education

Table 6: Challenges, Limitations, and Ethical Considerations and Related Frameworks & Reviews

Challenge/Limitation/Ethical Consideration	Reviews
Constraints of AI Chatbots	Ergene & Ergene, 2024
Limitations of AI-based assessment	Lee et al., 2024
Limitations of AI compared to traditional teaching	Ramprakash et al., 2024
Limitations of AI Mathematical Modelling	Spreitzer et al., 2024

Table 6 presents the challenges, limitations, and ethical considerations that arise with the use of AI tools in education (RQ4). Studies have shown that AI chatbots and learning tools, such as those by Ergene & Ergene, (2024) have a set of limitations and considerations that must be taken into account. There are also questions about AI and its ability to perform high level mathematical analysis and provide detailed responses as was highlighted by (Lee et al., 2024) and Spreitzer et al., (2024). Further, the ability of AI to provide robust educational experiences was questioned when compared to traditional teaching (Ramprakash et al., 2024). These factors align with a critical theory framework, which emphasizes that it is important to question and understand new technologies, to ensure they do not inadvertently perpetuate inequality and bias.

Discussion

This systematic literature review maps the landscape of AI in mathematics education, highlighting innovative strategies, reported successes, and key factors for effective implementation. Through a synthesis of recent research, this review reveals both AI's transformative potential and the practical and ethical challenges of its integration. The aim is to provide a balanced understanding of how AI can be leveraged effectively and responsibly to enhance mathematics education for all learners.

The review highlights diverse integration strategies (RQ1), ranging from AI-powered tutors like MathGPT and Flexi 2.0, which have shown positive results in calculus instruction (Alvarez, 2024), to AI chatbots integrated into e-textbooks (Ergene & Ergene, 2024) and AI chatbots used specifically for tutoring (Jančařík et al., 2023). Other approaches included AI-enhanced exam preparation platforms (Slobodsky et al., 2024) and the use of AI to update traditional teaching methods such as in calculus classes (Torres-Peña et al., 2024). This variety, viewed through the Situated Cognition perspective, emphasizes that AI tools are not a one-size-fits-all solution, but rather that their effectiveness is directly tied to the specific context and the ways they are incorporated into existing learning practices, rather than being used as a tool in isolation. The type of tool, whether a tutor or a system to prepare for exams, needs to be clearly defined and considered in its practical application.

Several studies show that AI enhances student learning (RQ2). AI-powered tutors have been shown to increase test scores, improve the learning experiences, and create dynamic classrooms (Torres-Peña et al., 2024). In addition, AI can increase student satisfaction with the learning experience, particularly in relation to test preparation (Moral-Sánchez et al., 2023; Slobodsky et al., 2024). The automated systems also allow for enhanced teacher discourse and an increase in learning for students (Suresh, 2022). When these findings are viewed through the TPACK framework, the importance of the interaction between technology, pedagogy and content all converge to demonstrate a productive learning environment. For this to occur effectively, it is not enough to simply have technology, but to also know *how* and *when* to integrate it, and to whom. The focus should also be on how to enhance the content of learning and to improve on current teaching practices.

Key factors contributing to successful AI implementation (RQ3) include the need for both educators and learners to adapt to new technologies (Almarashdi et al., 2024), as well as have a good conceptualization of the AI tools and their affordances (Ergene & Ergene, 2024). This requires a clear understanding of how the tools work in practice. Further, effective integration strategies (Stefanova & Georgiev, 2024), along with the need to update teaching practices to align with new technologies (Torres-Peña et al., 2024), must be taken into consideration. The TPACK framework is further highlighted here, showing the importance of a deep understanding of both the technology and the pedagogy of teaching mathematics, where teachers must be seen as guides for the technology. This means teacher training and autonomy should be at the center of implementation strategies to ensure the best outcomes.

However, the review also reveals ethical considerations and limitations (RQ4). AI tools themselves have their own inherent constraints (Ergene & Ergene, 2024; Lee et al., 2024; Ramprakash et al., 2024; Spreitzer et al., 2024). Furthermore, there is the very real risk of perpetuating bias with AI algorithms (Lee et al., 2024; Ramprakash et al., 2024; Spreitzer et al., 2024; Suresh, 2022), which is crucial to account for. It is imperative that technology not be seen as neutral, and that it is critical to actively assess the ethical implications, power dynamics, and access, which are often shaped by societal inequalities. The limitations highlight the importance of a carefully structured ethical framework and assessment strategies, so that these problems may be properly addressed.

Moreover, these limitations are directly tied to the algorithms that are being implemented, where data can be skewed or biased. To mitigate these issues, educators should be implementing bias-detection techniques (including testing using protected demographic information) and choosing tools that explicitly address these challenges. In addition, ethical frameworks for implementation should include data privacy and consent guidelines that are fully transparent and used consistently. There is a need to question technology, assess potential harms, and look to create systems that are both inclusive and equitable.

Recommendations, as informed by TPACK, include that educators use AI as a tool for transformation, but also that there should be robust professional development that includes training on technology and pedagogy for AI based math education. From a Situated Cognition perspective, learners must learn and grow from AI tools in a contextual environment designed for learner and community specific needs, and that the technology needs to fit into the larger goals for education. Policymakers should develop and implement regulatory frameworks to address data privacy, algorithmic biases and ensure equitable access, while also funding research that addresses these ethical considerations. Finally, researchers must prioritize longitudinal studies, develop best practices for bias mitigation and data privacy, and include student voices to better understand the ethics and effects of AI implementation in math education, and should work collaboratively to create a safe and ethical learning space for all learners, in line with the vision of NEP 2020. The core understanding of the work that needs to be done going forward rests on the idea that collaboration between stakeholders and ethical frameworks is essential.

Conclusion

This systematic literature review has explored the multifaceted landscape of AI in mathematics education, focusing on innovative strategies, reported positive impacts, key success factors, limitations, and ethical considerations. By synthesizing recent research, we have uncovered both the remarkable promise of AI to transform mathematics teaching and learning, and the crucial practical and ethical challenges that must be addressed for responsible and effective implementation. As highlighted by the Situated Cognition perspective, this review underscores that AI is not a magic bullet but a mediator of learning practices, where careful consideration of context and design is paramount. The review has showcased the diverse ways AI is being used, from personalized tutoring systems and AI chatbots to platforms that support exam preparation and provide automated feedback, highlighting how these tools shape specific learning experiences.

While AI demonstrates the potential to enhance student learning outcomes, particularly in areas like engagement and test preparation, this research, through the lens of the TPACK framework, emphasizes the critical role of educators in integrating these tools effectively. This means ensuring that AI is not simply *used*, but that it's used *well*, with a focus on the best practices and teaching methods. Recognizing the limitations and biases that must be carefully addressed, the review, through Critical Theory, advocates for ongoing evaluation of these tools with a critical lens, to ensure equity, access, and the elimination of unfair biases. Furthermore, the research advocates for AI to be integrated through a collaborative approach where it is used to supplement, rather than replace traditional methods, while also working to empower educators and learners.

References

Almarashdi, H. S., Jarrah, A. M., Khurma, O. A., & Gningue, S. M. (2024). Unveiling the potential: A systematic review of ChatGPT in transforming mathematics teaching and learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(12). Scopus. https://doi.org/10.29333/ejmste/15739

Alvarez, J. I. (2024). Evaluating the impact of ai–powered tutors mathgpt and flexi 2.0 in enhancing calculus learning. *Journal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(2), Article 2. https://doi.org/10.22437/jiituj.v8i2.34809

Baral, S., Lucy, L., Knight, R., Ng, A., Soldaini, L., Heffernan, N. T., & Lo, K. (n.d.). DrawEduMath: Evaluating Vision Language Models with Expert-Annotated Students' Hand-Drawn Math Images. *2024*.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated Cognition and the Culture of Learning. *Instittution of Inquiry*.

Ergene, O., & Ergene, B. C. (2024). AI ChatBots' solutions to mathematical problems in interactive e-textbooks: Affordances and constraints from the eyes of students and teachers. *Education and Information Technologies*. Scopus. https://doi.org/10.1007/s10639-024-13121-z

Ilic, P., Casebourne, I., & Wegerif, R. (2024). Introduction: Constructive Dialogue Between Technology and Pedagogy. *Intelligent Systems Reference Library*, *261*, 1–15. Scopus. https://doi.org/10.1007/978-3-031-71232-6_1

Jančařík, A., Michal, J., & Novotná, J. (2023). Using AI Chatbot for Math Tutoring. *Journal of Education Culture and Society*, *14*(2), 285–296. https://doi.org/10.15503/jecs2023.2.285.296

Källberg, P. S., & Roos, H. (2025). Meaning(s) of a student perspective in mathematics education research. *Educational Studies in Mathematics*. https://doi.org/10.1007/s10649-024-10374-w

Lave, J., & Wenger, E. (2009). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Lee, U., Kim, Y., Lee, S., Park, J., Mun, J., Lee, E., Kim, H., Lim, C., & Yoo, Y. J. (2024). Can we Use GPT-4 as a Mathematics Evaluator in Education?: Exploring the Efficacy and Limitation of LLM-based Automatic Assessment System for Open-ended Mathematics Question. *International Journal of Artificial Intelligence in Education*. https://doi.org/10.1007/s40593-024-00448-4

Mishra, P., & Koehler, M. J. (2006). *Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge*.

Moral-Sánchez, S. N., Rey, F. J. R., & Cebrián-de-la-Serna, M. (2023). Analysis of artificial intelligence chatbots and satisfaction for learning in mathematics education. *IJERI: International Journal of Educational Research and Innovation*, *20*, Article 20. https://doi.org/10.46661/ijeri.8196

Opesemowo, O. A. G., & Adewuyi, H. O. (2024). A systematic review of artificial intelligence in mathematics education: The emergence of 4IR. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(7). Scopus. https://doi.org/10.29333/ejmste/14762

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71

Panqueban, D., & Huincahue, J. (2024). Artificial Intelligence in Mathematics Education: A Systematic Review. *Uniciencia*, *38*(1). Scopus. https://doi.org/10.15359/ru.38-1.20

Ramprakash, B., Surya Devi, B., Nithyakala, G., Bhumika, K., & Avanthika, S. (2024). Comparing Traditional Instructional Methods to ChatGPT: A Comprehensive Analysis. *Journal of Engineering Education Transformations*, *37*(Special Issue 2), 612–620. Scopus. https://doi.org/10.16920/jeet/2024/v37is2/24095

Slobodsky, P., Durcheva, M., & Kugel, L. (2024). Enhancing Students' Preparation for Math Exams using the Advanced Features of the Halomda Platform. *International Journal for Technology in Mathematics Education*, *31*(1), 21–28. https://doi.org/10.1564/tme_v31.1.03

Song, D. (2017). Designing a Teachable Agent System for Mathematics Learning. *Contemporary Educational Technology*, *8*(2). https://doi.org/10.30935/cedtech/6194

Spreitzer, C., Straser, O., Zehetmeier, S., & Maaß, K. (2024). Mathematical Modelling Abilities of Artificial Intelligence Tools: The Case of ChatGPT. *Education Sciences*, *14*(7), 698. https://doi.org/10.3390/educsci14070698

Stefanova, T., & Georgiev, S. (2024). POSSIBILITIES FOR USING AI IN MATHEMATICS EDUCATION. *Mathematics and Education in Mathematics*, *53*, 117–125. Scopus. https://doi.org/10.55630/mem.2024.53.117-125

Suresh, A. (2022). *Automating Feedback to Improve Teachers' Effective Use of Instructional Discourse in K-12 Mathematics Classrooms*. University of Colorado.

Torres-Peña, R. C., Peña-González, D., Chacuto-López, E., Ariza, E. A., & Vergara, D. (2024). Updating Calculus Teaching with AI: A Classroom Experience. *Education Sciences*, *14*(9). Scopus. https://doi.org/10.3390/educsci14091019

Weigand, H.-G., Trgalova, J., & Tabach, M. (2024). Mathematics teaching, learning, and assessment in the digital age. *ZDM – Mathematics Education*, *56*(4), 525–541. https://doi.org/10.1007/s11858-024-01612-9