MANGAL RESEARCH JOURNAL **Received:** 27-08-2025 **ISSN:** 2773-7802
Volume 6, December 2025, **pp:** 21-32 **Accepted:** 11-11-2025 **DOI:** https://doi.org/10.3126/mrj.v6i1.88145

AI Use in Mathematics Education: Applications, Benefits, and Challenges

Bed Prasad Dhakal, PhD

Central Department of Education, Tribhuvan University, Kirtipur, Kathmandu, Nepal
Email: bed.dhakal@cded.tu.edu.np
ORCID : 0000-0002-1510-5046

Abstract

The study explores the emerging role of Artificial Intelligence (AI) in mathematics education by systematically reviewing recent empirical and conceptual research published between 2020 and 2025. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, fourteen relevant articles were selected through defined screening and evaluation procedures. The review identifies three major applications of AI in mathematics education—personalized learning, problem-solving support, and content generation—and three major benefits, namely enhanced learning engagement and motivation, deeper conceptual understanding, and improved accessibility and convenience. Likewise, three critical challenges are recognized: issues of accuracy and reliability, reduced human interaction, and misalignment with existing curricula. The findings suggest that while AI presents transformative potential in mathematics teaching and learning, its integration should be grounded in pedagogical reflection, ethical awareness, and curriculum innovation. The study concludes that AI, when thoughtfully integrated with human intelligence, can reshape mathematics education toward more interactive, inclusive, and learner-centered practices.

Keywords*:* Artificial intelligence, digital learning, mathematics education, teacher perception,

Introduction

The use of Artificial Intelligence (AI) is rapidly growing as a transformative digital tool in the educational landscape. Its application has opened new pedagogical approaches and reshaped traditional learning cultures worldwide, including Nepal, where the adoption of digital technologies in education is gradually expanding. In the literature, Şahin and Teke (2025) note that *"AI is becoming a rapidly growing topic in education, with its influence extending to all aspects of educational content, including mathematics."* Similarly, Mredula et al. (2024) discuss that the innovation of Generative AI (GenAI) tools—such as ChatGPT and MathGPT—has introduced conversational data generation processes, where models learn from large training datasets and big data patterns. These developments have gained significant attention in educational settings, transforming how learners interact with information and acquire knowledge.

The potential of human-like content creation and human-like conversation through AI and Generative AI (GenAI) has drawn increasing attention in educational practices such as teaching, learning, and assessment. Students have begun using these tools for learning,

homework, and assignments, which has personalized their learning experiences. For example, Walkington (2025) argues that *"AI tools support students through human-like conversations and assist with responses to questions across multiple disciplines."* In mathematics, this kind of response accuracy is improving rapidly, even for complex problem-solving tasks.

The trend of using digital and AI tools has already begun in Nepal, not only in higher education but also in school education. However, based on practical experience, its *pedagogical framework, practical applications, and implications* are yet to be fully explored. Many concerned stakeholders have started adopting AI as an instructional strategy. As Stefanova and Georgiev (2024) point out, *"the use of AI can serve as a potential strategy to enhance students' learning outcomes, even in mathematics."* In Nepal, the results of the Secondary Education Examination (SEE) indicate an urgent need for innovative teaching methods to improve students' performance, particularly in mathematics. According to several news reports, the shortage of qualified mathematics teachers is also increasing in some regions. Consequently, the use of technology is gradually transforming traditional pedagogical approaches.

In their research, Şahin and Teke (2025) reported that *"the integration of AI into educational governance is transforming traditional practices, moving from a one-size-fits-all teaching model toward more student-centred learning."* As a teacher educator, I have also observed that the thoughtful use of AI can provide various types of learning support—such as assisting in searching, reading, completing assignments, and developing projects. AI applications are useful and adaptable to diverse learning contexts and learner preferences. For example, in my own teaching practice, I have used AI tools for lesson planning, preparing supplementary learning materials, and producing mathematics tutoring videos to enhance students' understanding.

With this background, the present systematic review aims to provide evidence-based insights into the potential role of Artificial Intelligence (AI) in mathematics education. Drawing on recent research, the study explores how AI has been applied to support teaching and learning, focusing on its major applications, benefits, and challenges. Through a systematic review of published literature, it further analyzes how teachers can integrate AI to enhance their instructional practices and how students can use AI to improve their learning experiences and outcomes in mathematics.

Accordingly, this study seeks to address the following research question: What are the potential applications, opportunities, and challenges of using Artificial Intelligence in mathematics education?

Methods

This study adopted a systematic literature review approach to explore the current use of artificial intelligence (AI) in mathematics education, with emphasis on its applications, benefits, and challenges. The review followed general PRISMA principles to maintain transparency and ensure replicability of the process.

Relevant peer-reviewed journal articles were collected from ERIC, Scopus, Google Scholar, SpringerLink, and ScienceDirect, focusing on publications between 2018 and 2025. The search used a combination of keywords such as *AI in mathematics education, intelligent tutoring systems, adaptive learning, machine learning in education,* and *AI-based pedagogy.* Studies were included if they examined AI tools or models applied to mathematics teaching, learning, or assessment. Conference papers, book chapters, and non-empirical reports were excluded.

The selected studies were read carefully to extract data on research purpose, design, participants, AI applications, and major outcomes. The analysis used a thematic synthesis approach, organizing the findings into key dimensions: AI applications in mathematics education, pedagogical and learning benefits, and challenges and limitations of implementation.

As the study relied solely on published sources without involving human participants, no ethical clearance was required.

Results and Discussion

This study is a systematic literature review (SLR) conducted to address the research question: *"What are the potential applications, opportunities, and challenges of using Artificial Intelligence (AI) in mathematics education?"* The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to identify, screen, and analyze relevant research. A total of fourteen peer-reviewed articles published between 2018 and 2025 were reviewed for this purpose. Based on the analysis, the key results are presented and discussed under major thematic areas below.

Applications of AI in Mathematics Education

The analysis of fourteen reviewed articles revealed that the applications of Artificial Intelligence (AI) in mathematics education range from personalized learning support to content generation and pedagogical innovation. The main areas of application identified include: (i) personalized learning, (ii) problem solving, and (iii) content generation.

Personalized Learning

The growing use of AI has created new opportunities for personalized learning. Learners increasingly use AI tools such as ChatGPT, Cici, Copilot, Gemini, and Perplexity to ask questions and receive prompt-based responses. These systems generate contextually

appropriate feedback, helping learners to clarify concepts and strengthen problem-solving abilities. As Mredula et al. (2024) mention, *"Chatbots such as ChatGPT, Copilot, Gemini, and virtual tours are widely utilized for problem-solving assistance, conceptual clarification, and continuous learning support."*

The use of AI continues to expand with the development of Intelligent Tutoring Systems (ITS) that provide customized feedback similar to that of a human teacher. Dabingaya (2022) noted that *"AI-based tutoring systems can provide instruction based on individual needs, analyze students' performance, and identify their learning strengths and weaknesses."* For example, in Algebra, AI assists with pattern recognition and equation solving; in Geometry, it offers dynamic visualization; in Arithmetic, it supports automated practice; and in Statistics, it facilitates data plotting, interpretation, and analysis.

Because mathematics is a discipline grounded in logic and algorithms, AI tools have proven remarkably effective in assisting learning. Mredula et al. (2024) identified systems such as *MathBERT, Khanmigo, ALEKS,* and *MATHia* as highly effective in supporting learners and complementing traditional classroom practices. However, as the author argues, these systems should supplement rather than replace conventional teaching methods. While AI tools increasingly enhance mathematics teaching and learning, *"AI can never fully replace human teachers or human interaction,"* as learning also involves emotional and social engagement. Therefore, the future of mathematics education should be viewed as a collaboration between AI tools and human teachers, harmonizing digital intelligence with human empathy.

Problem Solving

Problem solving and reasoning lie at the heart of mathematics learning. AI tools are becoming indispensable in assisting learners with these skills. Walkington (2025) observed that *"AI tools can help mathematics learners by suggesting problem-solving strategies, often with step-by-step solutions, hints on relevant formulas and reasoning, and suitable feedback."*

From the author's professional experience, AI has also been instrumental in mathematical modeling and theorem proving, supporting learners in both conceptual and procedural tasks. However, the author emphasizes that learning pace and cognitive needs vary among students, and emotional support remains critical. Hence, although AI can enhance problem-solving efficiency, human guidance remains paramount to ensure emotional encouragement and sustained learner confidence. The future of mathematics education, therefore, must blend AI assistance with human mentorship to preserve the holistic learning experience.

Figure 1: Applications of AI in Mathematics

Content Generation

Mathematics, while globally standardized, can be locally contextualized to enhance learner engagement. AI is emerging as a transformative tool for educators to create contextually rich educational resources—including texts, images, videos, and simulations. Fu (2024) & Oh (2025) reported that *"AI can generate contextualized math problems, linking them to local examples and producing interactive visualizations."*

In classroom practice, the author has also used AI tools in combination with programming software such as Mathematica, GeoGebra, JavaScript, and Python to generate learning materials tailored to local contexts. For instance, Walkington (2025) discussed that *"AI can make mathematical problems more readable and align them better with students' interests."* Similarly, Normuminov (2025) highlighted the use of Curipod for creating interactive, slide-based lessons. Oh (2025) further noted that *"AI supports lesson creation, quiz generation, assignment design, and automating administrative tasks, thereby reducing workload and improving efficiency."*

AI's role in content generation thus enables teachers to design differentiated learning materials suited to varied learning styles and emotional needs. Tools such as LaTeX/Overleaf (for text), GeoGebra (for images), OBS Studio (for videos), JavaScript (for simulations), and Scratch or Python (for projects) are now common AI-assisted applications in mathematics education. However, the most effective results arise when AI and human educators collaborate, combining technological precision with pedagogical expertise. AI helps teachers and learners reclaim time from repetitive tasks, allowing them to focus on creativity, empathy, and human-centered learning.

Benefits of AI in Mathematics Education

The review of fourteen selected studies revealed that the benefits of Artificial Intelligence (AI) in mathematics education range from enhancing learner engagement and motivation to deepening conceptual understanding and improving accessibility to learning opportunities. These benefits are summarized under three main themes below.

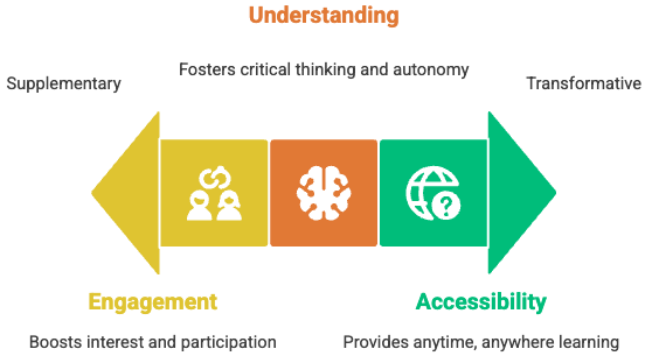

Figure 2: Benefits of AI in Mathematics

Enhanced Learning Engagement and Motivation

Students learn more effectively when learning is engaging, interactive, and student-centred. In such contexts, AI tools have gained increasing popularity. Luzano (2024) & Ajuwon et al. (2024) reported that *"AI tools make learning more interactive and enjoyable, increasing students' interest and participation."* Integration of AI in pedagogy has therefore drawn attention for its potential to promote student engagement, and made classroom activities more dynamic and interactive.

From the author's own experience as a mathematics educator, AI tools can support teachers gamify and personalize learning content, which keeps students attentive and motivated. Dabingaya (2022) also found that *"students who use AI tools often achieve higher test scores and demonstrate better comprehension and long-term retention of mathematical concepts."* Nevertheless, the teacher's thoughtful intervention remains essential. Educators must decide what AI to use and how to deploy it purposefully, inspiring learners at both emotional and intellectual levels. Future mathematics classrooms are likely to be shaped by effective collaboration between human intelligence (HI) and artificial intelligence (AI) to foster curiosity, engagement, and deeper interest in learning.

Deeper Conceptual Understanding

AI tools can provide step-by-step explanations, multiple problem-solving strategies, and adaptive feedback that support deep learning. Several studies (e.g., Pala et al., 2025; Stefanova and Georgiev , 2024; Taufik & A., 2025) highlight that *"AI helps learners understand mathematical problems, their solutions, and underlying strategies, thereby broadening conceptual understanding."* Also, Intelligent Tutoring Systems (ITS) and chatbots have been found particularly effective in supporting on-demand learning and individualized explanation.

As the author observes, AI promotes deeper understanding because learners can access real-time assistance when they most need it. AI applications can automate learning tasks

such as warm-ups, quizzes, grading, and feedback. Stefanova and Georgiev (2024) noted that such activities can *"free up learners' time for higher-order learning activities."* This self-paced learning approach empowers students to manage their learning independently while encouraging critical reflection. Thus, AI functions as a supplementary learning partner that nurtures learners' autonomy, helping them to detect errors, reflect, and strengthen self-accountability in their learning journey.

Improved Accessibility

AI tools have made mathematics learning more accessible, even in remote or resource-limited areas. Since many AI-based applications operate through mobile devices or web platforms, learners can now access information *anytime and anywhere*. Pala et al. (2025) found that *"AI tools can support learners with instant access to information and provide opportunities to learn any time anywhere at their own pace."*

AI integration in education has thus become a game-changer—increasing both equity and opportunity. Oh (2025) reported that *"AI use has promoted teachers' confidence and creativity in lesson design by providing new and innovative ideas, thus augmenting their professional practice."* Such evidence indicates that the effective use of AI can reshape mathematics education by promoting inclusiveness and enriching the teaching profession.

Challenges of AI in Mathematics Education

The reviewed studies also identified several challenges associated with the use of AI in mathematics education, particularly in the context of developing countries like Nepal. The three major concerns are accuracy and reliability, reduced human interaction, and curriculum alignment, which are shown as follows.

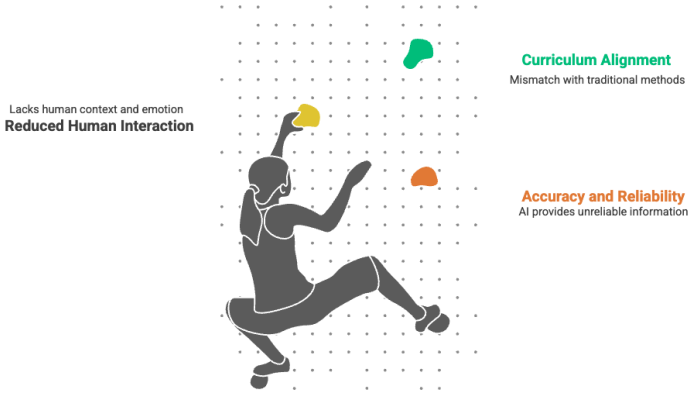

Figure 3: Challenges of AI use in Mathematics

Accuracy and Reliability

AI tools, especially Large Language Models (LLMs) such as ChatGPT and other generative systems, sometimes produce inaccurate or unreliable information. Walkington

(2025) cautioned that *"AI tools can occasionally provide incorrect, inconsistent, or irrelevant information or solutions when training data contain bias or outdated information."* Because AI systems rely on pattern recognition, they can generate "hallucinations"—confident but fabricated responses. This may lead to superficial learning, where short-term progress occurs at the expense of deeper comprehension (Oh, 2025).

Hence, AI-generated results require expert verification before being used in academic or instructional contexts. As mathematics involves logic and computation, even minor inaccuracies can mislead learners. The author agrees that *AI should be viewed as a supportive tool, not an infallible authority,* and students must be trained to critically evaluate its outputs using credible sources.

Reduced Human Interaction

Learning is inherently a human process that involves emotion, empathy, and moral context. Since Ai is based on computer program, AI generated information can lack human context, intuition, and moral values. Oh (2025) emphasized that *"AI-generated information might lack feeling of human touch and context, so it may reduce human to human interaction like teacher–student interaction and interactions."* This loss of interpersonal connection can diminish the emotional dimension of learning.

Education is grounded in values, ethics, and culture—elements that algorithms cannot fully capture. Normuminov (2025) argued that educators need to acquire AI literacy and prompt engineering skills to use AI effectively while retaining human-centered pedagogy. Although AI supports efficiency, human intelligence remains essential for empathy, judgment, and ethical decision-making. Therefore, the ultimate goal of education should be to use AI without replacing HI (Human Intelligence). Moreover, despite AI's ongoing progress, Human Intelligence (HI) should be always there for holistic, and emotionally grounded teaching and learning activities.

Curriculum Alignment

In Nepal, the increasing use of AI in mathematics education has raised concerns about curriculum alignment. The current curriculum remains largely traditional, emphasizing rote learning, problem solving, and paper-based tests—all of which can now be automated through AI tools. Stefanova and Georgiev (2024) highlighted *"the need to revise mathematics curricula to integrate AI and address its pedagogical implications."*

Moreover, Ajuwon et al. (2024) warned that issues such as plagiarism, data privacy, and algorithmic bias must be addressed through updated curricula. Educational institutions should therefore innovate a new "culture of experimentation using AI and digital laboratory" to encourage creative and ethical innovation. Without curriculum alignment, AI integration could widen the digital divide, further deepening inequalities in education.

Conclusion and Implications

The rapid advancement of Artificial Intelligence (AI) has introduced a transformative shift in the pedagogy of mathematics education, reshaping how learners engage with content and how teachers design instruction. The review of fourteen studies reveals that AI has the potential to make mathematics learning more interactive, adaptive, and inclusive. Şahin and Teke (2025) noted that *AI tools provide opportunities to enhance student engagement and learning experiences, particularly in mathematics.* Similarly, Dabingaya (2022) reported that adaptive learning platforms and content generators have supported greater student participation, improved understanding, and measurable gains in learning outcomes.

In the context of Nepal, the findings indicate that thoughtful and ethically grounded integration of AI remains a pressing need. Despite growing awareness, the effective use of AI depends largely on the digital and AI literacy of both teachers and students. As Şahin and Teke (2025) emphasized, critical adoption of AI requires strong literacy among educators and learners. Without adequate understanding of how AI systems function, their limitations, and their biases, the use of these tools may remain superficial. Manto et al. (2025) similarly suggested that pedagogical innovation must go beyond convenience toward meaningful transformation of teaching and learning practices.

The results also imply that teacher education programs must play a proactive role in this transformation. Oh (2025) highlighted that pre-service and in-service teacher training should include practical AI modules to build competence in integrating AI tools effectively. As AI transforms classroom dynamics, teachers' roles are evolving—from being transmitters of content to becoming facilitators, curators, and critical content creators (Normuminov, 2025). Properly used, AI can help teachers generate instructional materials, align content with higher-order thinking skills, and address learners' misconceptions (Walkington, 2025).

For this transformation to be sustainable, capacity building and reflective practice are essential. Effective integration of AI requires training in prompt engineering, enabling educators to design purposeful inputs for more accurate and pedagogically relevant outputs. Oh (2025) argued that well-crafted prompts can improve accuracy, minimize bias, and enhance classroom usefulness. In the same line, Stefanova and Georgiev (2024) recommended structured workshops that combine hands-on experience with ethical discussions, encouraging teachers to adopt an evidence-based mindset of innovation and reflection.

The study concludes that AI holds immense potential to support mathematics teaching and learning if used wisely and ethically. Its primary benefits include enhanced engagement, deeper conceptual understanding, and improved accessibility to learning

resources. At the same time, challenges related to accuracy, reduced human interaction, and curriculum alignment must be critically addressed to maximize these benefits.

In the Nepalese context, curriculum reform emerges as a key implication. The existing mathematics curriculum needs to be revisited and redesigned to integrate AI-assisted learning tools and digital strategies. Such reform would ensure that technological innovation aligns with Nepal's national education goals while maintaining contextual relevance. The inclusion of AI-supported pedagogical practices could help shift the focus from rote memorization toward creativity, problem-solving, and application-based learning.

Another important implication concerns teacher education and professional development. Teacher training institutions and universities should embed AI literacy, prompt design, and digital ethics into their training programs. These competencies would enable teachers to use AI confidently and critically, improving classroom delivery and learner engagement. Periodic workshops and in-service training sessions would further help teachers update their digital skills and share best practices for integrating AI into their lessons.

The study also implies the necessity of policy support and ethical governance. The government and educational policymakers need to develop clear guidelines on ethical AI use, including data privacy, transparency, and academic integrity. Policy frameworks should promote AI adoption not merely as a technological trend but as a pedagogically informed strategy to enrich learning experiences. Establishing national standards and monitoring mechanisms can ensure that AI tools are implemented responsibly across institutions.

Finally, the findings highlight the importance of equity, access, and innovation. To prevent a widening digital divide, it is vital that rural and community schools have equitable access to AI-supported learning resources and reliable internet connectivity. Universities and research centers in Nepal should also encourage further studies to examine how AI affects learning motivation, classroom engagement, and educational equality. By investing in local innovation and research, Nepal can adapt global AI trends to its own educational needs and realities.

In conclusion, the thoughtful adoption of AI offers a promising avenue to modernize mathematics education in Nepal. With coordinated efforts in curriculum reform, teacher capacity building, and ethical policy design, AI can help create a more engaging, inclusive, and intellectually vibrant learning environment—one that balances technological advancement with the human essence of teaching and learning.

References

Dabingaya, M. (2022). Analyzing the Effectiveness of AI-Powered Adaptive Learning Platforms in Mathematics Education. *Interdisciplinary Journal Papier Human Review, 3*(1), 1–7. https://doi.org/10.47667/ijphr.v3i1.226

Fu, A. (2024). Investigation of recent advances related to AI in mathematics education. *Applied and Computational Engineering, 37*(1), 86–89. https://doi.org/10.54254/2755-2721/37/20230476

Luzano, J. F. P. (2024). Reshaping Mathematics Instruction Via Impact of AI Chatbots on Secondary Education Pre-service Teachers. *International Journal of Studies in Education and Science, 5*(3), 233–245. https://doi.org/10.46328/ijses.97

Manto, A. M., Señedo, G. E., Jauculan, F. G. E., Giangan, M. S. Q., & Alcantara, G. A. (2025). AI Literacy Among Future Math Educators: The Mediating Role of Digital Literacy in Mathematics Teaching. *International Journal of Learning, Teaching and Educational Research, 24*(7), 753–775. https://doi.org/10.26803/ijlter.24.7.37

Mredula, N. K., Jonita, N. R., & Sajja, N. P. (2024). AI-Based Tools in Mathematics Education: A Systematic review of characteristics, applications, and evaluation methods. *International Research Journal on Advanced Engineering Hub (IRJAEH)*, *2*(07), 1958–1967. https://doi.org/10.47392/irjaeh.2024.0268

Normuminov, M. (2025). Empowering Pre-Service English Teachers through AI-Based lesson Design: a case study on Curipod. *Journal of Digital Sociohumanities*, *2*(2), 142–149. https://doi.org/10.25077/jds.2.2.142-149.2025

Oh, S. (2025). Integration of MATH41 and Generative AI in Pre-Service Mathematics Teacher Education: An Empirical Study on Lesson Design Competency. *IEEE Access*, *13*, 128959–128973. https://doi.org/10.1109/access.2025.3586593

Ajuwon, N. O. A., Animashaun, N. E. S., & Chiekezie, N. N. R. (2024). Innovative teaching strategies in mathematics and economics education: Engaging students through technology, AI, and Effective Mentoring. *Open Access Research Journal of Science and Technology*, *11*(2), 128–137. https://doi.org/10.53022/oarjst.2024.11.2.0103

Pala, C. A., Lagrimas, D., & Jr., M. L. N. (2025). Exploration of Chatbots in Mathematics Education for Innovative Learning Process. *Asian Journal of Advanced Research and Reports, 19*(5), 178–194. https://doi.org/10.9734/ajarr/2025/v19i51010

Şahin, S., & Teke, B. (2025). Artificial Intelligence Integration in Mathematics Education: A SWOT-BWM Analysis. *Journal of Learning and Teaching in Digital Age, 10*(2), 273–286. https://doi.org/10.53850/joltida.1667650

Stefanova, T., & Georgiev, S. (2024). Possibilities for using AI in mathematics education. *Mathematics and Education in Mathematics*, *53*, 117–125. https://doi.org/10.55630/mem.2024.53.117-125

Taufik, M., & A, S. (2025). Integrating hybrid learning, YouTube tutorials, and AI tools to enhance student engagement and achievement in introductory physics: A Mixed-Methods Study in Mathematics Education. *Jurnal Ilmiah Profesi Pendidikan*, *10*(2), 1953–1957. https://doi.org/10.29303/jipp.v10i2.3634

Walkington, C. (2025). The implications of generative artificial intelligence for mathematics education. *School Science and Mathematics*. https://doi.org/10.1111/ssm.18356