ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Artificial Intelligence in School-Level Mathematics Education: A Comprehensive Review

Mary Nirmala, Y. Dominic Ravichandran

DMI-St. Eugene University, Lusaka, Zambia.

DOI: https://doi.org/10.51244/IJRSI.2025.120700187

Received: 22 July 2025; Accepted: 28 July 2025; Published: 16 August 2025

ABSTRACT

The integration of artificial intelligence (AI) into school-level mathematics education has advanced rapidly in recent years, fundamentally reshaping instructional practices and student learning experiences. This review synthesizes current literature to provide a comprehensive overview of AI's applications within mathematics classrooms, focusing on personalized learning, adaptive assessment, evolving teacher roles, ethical considerations, and emerging global trends. The analysis highlights AI's potential to enhance student engagement, improve academic achievement, and promote educational equity. However, it also underscores the necessity of thoughtful implementation, robust teacher support, and the development of clear policies to address associated challenges. The review concludes that, while AI holds transformative promise for mathematics education, its successful integration depends on balancing technological innovation with pedagogical integrity and ethical responsibility. Future research and policy efforts are essential to ensure AI's benefits are equitably realized across diverse educational contexts.

Keywords: Artificial intelligence, Gamification, Mathematics, DreamBox, ALEKS.

INTRODUCTION

Historically, mathematics education has been grounded in traditional methods such as direct instruction, repetitive practice, and standardized testing. These approaches have long dominated classrooms in many parts of the world, particularly in countries like India and Zambia, where examination-driven instruction and rigid curricula remain prevalent. In India, for instance, over 80% of public school teachers still rely on lecture-based delivery (MHRD, 2021), while in Zambia, national assessments indicate that only 45% of Grade 9 students achieve proficiency in mathematics (Zambia Education Performance Report, 2023).

However, the onset of artificial intelligence has ushered in a transformative era for educators and learners alike. AI's potential to revolutionize educational practices is increasingly being recognized by policymakers, practitioners, and researchers. AI technologies such as intelligent tutoring systems, natural language processing, and adaptive learning platforms enable more dynamic, personalized, and responsive learning experiences. These tools allow for real-time feedback, data-driven instruction, and customized pathways that accommodate diverse learner needs (Das et al., 2025; Wang et al., 2025).

Globally, the adoption of AI in education is growing rapidly. A UNESCO report (2023) notes that more than 30 countries have launched national AI-in-education initiatives, with significant investments in digital infrastructure and teacher training. In India, the National Education Policy (NEP 2020) emphasizes the integration of technology, including AI, into classroom instruction and assessment. The Government of Zambia, through its Smart Zambia Initiative, is exploring the role of emerging technologies, including AI, in addressing challenges in the education sector (Liswaniso & Mbale, 2024).

Despite the promise, disparities in digital access and capacity building pose significant challenges, particularly in low-resource settings. As such, understanding how AI is reshaping mathematics education at the school level across varied global contexts is both timely and essential (Bulathwela et al., 2024). This review seeks to consolidate and critically evaluate current findings from the literature published between 2020 and 2025 to

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

understand the ways AI is influencing teaching, learning, and educational equity in mathematics classrooms. The conceptual model to link AI tools to learning outcomes is presented in Figure 1.

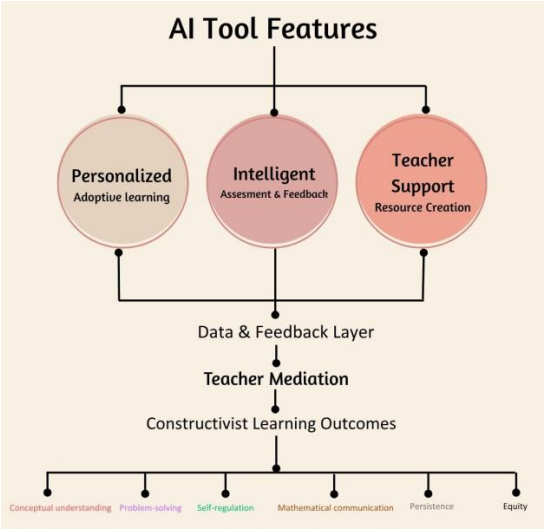

Fig.1: Conceptual model to link AI tools to learning outcomes

METHODOLOGY

This review employed a systematic literature review methodology. Key databases searched included Scopus, Web of Science, Google Scholar, ERIC, and ScienceDirect. Search terms included combinations of "artificial intelligence," "mathematics education," "adaptive learning," "AI in classrooms," and "K-12 education." Studies were included if they: (a) focused on AI applications in mathematics education; (b) involved primary or secondary education contexts; and (c) were peer-reviewed publications from 2020 to 2025.

AI Applications in Mathematics Education

Artificial Intelligence (AI) has emerged as a transformative force in mathematics education, redefining how learners interact with content, how teachers deliver instruction, and how assessments are conducted. Recent advances have enabled AI to impact mathematics education across four key domains: adaptive and personalized learning, intelligent assessment and feedback, teacher support and resource creation, and student engagement and motivation (Tang, 2025; Sharma, 2024; Meylani, 2024).

Adaptive and Personalized Learning

AI-powered adaptive learning platforms are reshaping the traditional classroom by providing individualized learning experiences based on students' real-time performance and learning styles (Hwang & Tu, 2021). Systems such as DreamBox Learning and ALEKS (Assessment and Learning in Knowledge Spaces) employ machine learning algorithms to interpret students' input, learning pace, and patterns of misunderstanding, thereby enabling precise instructional adjustments (Feng et al., 2025; Xu & Ouyang, 2022). For instance, DreamBox Learning collects thousands of data points per hour to make instructional decisions tailored to each learner's cognitive profile. Similarly, ALEKS identifies what a student knows and is ready to learn next, creating a dynamic, personalized learning path (Feng et al., 2025). Khan Academy's AI tutor, Khanmigo, leverages natural language dialogue to scaffold problem-solving in a conversational format, supporting students as they construct understanding through guided reasoning (Hwang & Tu, 2021).

These adaptive tools have demonstrated improved learning outcomes, particularly in diverse and large classroom settings where differentiated instruction is challenging to implement manually (Xu & Ouyang, 2022). In rural India, adaptive platforms like Byju's and Gooru have enhanced access to quality math content in regional languages, while in various low-resource settings, AI-powered apps piloted in underserved schools have improved learning outcomes among students with limited access to qualified teachers (Goswami, &

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Sharma, 2024). A comparative major AI platform in mathematical education is summarized and given in Table 1.

Table 1: Major AI Platforms in Mathematics Education

Platform	Key Features	Pedagogical Focus	Adaptive?	Gamification	NLP Dialogue	Target Regions	Accessibility	Reference
DreamBox	Adaptive pathways; analytics; formative feedback	Concepts, skills	Yes	Some	No	US, India, LatAm, Africa	Multilingual, web	Feng et al., 2025; DreamBox Learning, 2024
ALEKS	Knowledge spaces mapping; mastery tracking	Problem-solving, fluency	Yes	Minimal	No	US, EU, select Africa/ Asia	Web, some offline	Feng et al., 2025; ALEKS Corporation, 2022
Khan Academy	AI-powered tutor (Khanmigo); video library	Reasoning, scaffolded problems	Some	Some	Yes	Global, incl. India, Zambia	Widest, offline	Hwang & Tu, 2021; Khan Academy, 2024
Byju's	Vernacular content; gamified path; analytics	Conceptual building	Some	Some	No	India, Africa, SE Asia	Mobile, multilingual	Goswami & Sharma, 2024; Byju's, 2023
Gradescope	Automated marking/ AI-based feedback for open-response	Assessment, formative feedback	No	No	No	US, EU, Australasia	English only	Meinel et al., 2024; Gradescope, 2023
Photomath	Visual recognition; stepwise explanations	Procedural fluency	Some	No	Some	Global	Mobile-focused	Okonkwo & Ade-Ibijola, 2021; Photomath, 2023
Prodigy/	Game-based	Motivation, basic	Yes	Extensive	No	US, UK,	Mobile,	Bledsaw, 2024;

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Matific	rewards environment	skills				SA, India, LatAm	web	Özcan Şahin & Özçakır Sümen, 2025; Prodigy Education, 2024

Intelligent Assessment and Feedback

AI technologies significantly enhance the accuracy, speed, and responsiveness of formative assessments. By leveraging natural language processing and machine learning, platforms such as Gradescope can automatically evaluate open-ended math problems, offer feedback, and track student progress over time. Gradescope, widely used in higher education, uses AI to cluster student responses and suggest feedback patterns for quicker grading, which helps instructors refine instruction in real time (Ion, 2024; Meinel et al., 2024; Ricci et al., 2023).

AI-based feedback has been shown to promote self-regulated learning by enabling students to reflect on their errors, revise their solutions, and build metacognitive skills (Mehmood et al., 2025). These technologies support personalized diagnostics, allowing educators to intervene precisely and effectively (Lourenço et al., 2025).

Teacher Support and Resource Creation

Beyond supporting students, AI offers significant value to teachers by automating routine tasks and generating tailored instructional resources (Almuhanna, 2024). AI-driven platforms assist educators in creating lesson plans, designing quizzes, and curating teaching materials aligned with curricular standards (Ejjami, 2024). These tools also help educators identify areas of low conceptual clarity across the class and adjust teaching strategies accordingly (Hwang & Tu, 2021).

By reducing administrative burdens and increasing instructional efficiency, AI allows teachers to focus more on mentoring, differentiation, and relationship-building (Dadhich et al., 2025).

Engagement and Motivation

AI-enhanced tools have demonstrated the ability to increase students' engagement, motivation, and positive attitudes toward mathematics (Xu, 2024). Gamified apps and AI-driven virtual tutors present content in interactive and visually engaging formats that are particularly appealing to digital-native learners (Swargiary, 2024). Apps such as Photomath and Socratic by Google use image recognition and natural language processing to interpret handwritten or printed math problems and provide step-by-step solutions. These tools not only help students solve problems but also explain the underlying concepts, improving conceptual understanding (Okonkwo & Ade-Ibijola, 2021).

Gamified platforms such as Prodigy Math and Matific integrate AI with reward-based learning environments, which are especially effective in early and middle years, where intrinsic motivation often requires external reinforcement (Bledsaw, 2024; Özcan Şahin & Özçakır Sümen, 2025). Studies have found that students who used AI-powered math games showed greater persistence and engagement compared to those using traditional workbooks (Banik, B. G., & Gullapelly, 2025).

Impact on Student Achievement and Equity

Academic Performance Several meta-analyses reveal that AI-enhanced learning environments contribute to improved academic outcomes in mathematics (Tlili et al., 2025). Fütterer et al. (2025) report test score gains in classrooms utilizing adaptive technologies.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Equity and Inclusion AI has the potential to bridge learning gaps for students with disabilities and those in under-resourced schools. By providing accessible formats and personalized learning pathways, AI facilitates inclusive learning environments (Opesemowo & Adewuyi, 2024). However, disparities in digital access and infrastructure still hinder widespread adoption in low-income areas.

Teacher and Student Perceptions Mixed-method studies suggest that both students and teachers generally perceive AI tools positively. Teachers acknowledge improvements in their capacity to differentiate instruction, while students appreciate instant feedback and personalized pacing (Song et al., 2025; Idowu, 2024).

Challenges and Ethical Considerations

Algorithmic Bias and Fairness Uncritical deployment of AI risks perpetuating systemic biases. Studies show that algorithms trained on non-representative data can disadvantage marginalized groups (Arriagada-Bruneau et al., 2024; Shen et al., 2024). Regular audits and transparency in AI model development are critical to promoting fairness.

Data Privacy and Security AI tools depend on vast amounts of student data, raising significant privacy concerns. Ethical frameworks and strict data governance policies are necessary to ensure compliance with data protection standards such as GDPR and FERPA (Chauhan & Dutta, 2025; Yang & Beil, 2024).

Teacher Roles and Professional Development While AI can automate some instructional functions, it cannot replace the nuanced judgment and empathy of teachers. Ongoing professional development is essential to equip educators with the skills to integrate AI effectively without compromising pedagogical integrity (Zou et al., 2025Yadav, 2024).

Global Trends and Research Collaboration

China and the United States are leading the way in AI applications in education, followed by South Korea, the UK, and Australia. There is a marked increase in international collaborations and cross-disciplinary research efforts. Recent bibliometric analyses highlight growing interest in generative AI and its educational applications (Kayyali, 2024; Alexandrowicz, 2024).

Future Directions

Curriculum Integration Curricula need to be revised to seamlessly integrate AI tools. This involves aligning digital competencies with mathematical learning outcomes.

Ethical AI Development There is an urgent need for ethical guidelines to govern AI tool design, focusing on transparency, fairness, and accountability.

Teacher Training and Support Pre-service and in-service training programs should incorporate modules on educational AI, including ethical use, data interpretation, and instructional design.

Hybrid Learning Models Blended learning models that combine AI-based instruction with traditional teaching strategies offer a balanced approach that leverages technology while maintaining the human element.

CONCLUSION

Artificial intelligence has the transformative potential to reshape school-level mathematics education, offering personalized, interactive, and efficient learning experiences for all students. However, realizing this promise depends on several key actions. Policymakers must develop comprehensive frameworks that guide the responsible use of AI in classrooms. Ethical safeguards should be established to protect student data, ensure transparency, and prevent bias. Additionally, ongoing capacity-building initiatives—such as teacher training and resource development—are essential to equip educators with the skills and tools needed to effectively integrate AI. By taking these concrete steps, stakeholders can harness AI's capabilities to promote equity and

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

excellence in mathematics education, ensuring that all learners benefit from innovative, high-quality instruction.

ACKNOWLEDGEMENTS

The authors thank the management of DMISEU for all the help and infrastructure for the completion of this work.

REFERENCES

1. ALEKS Corporation. (2022). ALEKS product overview. https://www.aleks.com/about_aleks.html
2. Alexandrowicz, V. (2024). Artificial Intelligence Integration in Teacher Education: Navigating Benefits, Challenges, and Transformative Pedagogy. Journal of Education and Learning, 13(6), 346-364.
3. Almuhanna, M. A. (2024). Teachers' perspectives of integrating AI-powered technologies in K-12 education for creating customized learning materials and resources. Education and Information Technologies, 1-29.
4. Arriagada-Bruneau, G., López, C., & Mendoza, M. (2025). Ethics in Artificial Intelligence and Information Technologies. CRC Press.
5. Banik, B. G., & Gullapelly, A. (2025). AI-Powered gamification and interactive learning tools for enhancing student engagement. In Driving Quality Education Through AI and Data Science (pp. 283-310). IGI Global Scientific Publishing.
6. Bledsaw, J. A. (2024). Investigating Prodigy Math Program to Improve Students' Success in Mathematics.
7. Bulathwela, S., Pérez-Ortiz, M., Holloway, C., Cukurova, M., & Shawe-Taylor, J. (2024). Artificial intelligence alone will not democratise education: On educational inequality, techno-solutionism and inclusive tools. Sustainability, 16(2), 781.
8. Byju’s. (2023). BYJU'S - The Learning App. https://byjus.com
9. Chauhan, S., & Dutta, A. (2025). ARTIFICIAL INTELLIGENCE IN STUDENT PRIVACY AND DATA SECURITY. International Journal of Advanced Research in Computer Science, 16(3).
10. Dadhich, A., Yadav, R., Yadav, M., Huzooree, G., & Dewasiri, N. J. (2025). Teacher-AI Collaboration and the Future of the Educator's Role. In Transformative AI Practices for Personalized Learning Strategies (pp. 355-378). IGI Global Scientific Publishing.
11. Das, S., Mutsuddi, I., & Ray, N. (2025). Artificial intelligence in adaptive education: A transformative approach. In Advancing adaptive education: Technological innovations for disability support (pp. 21-50). IGI Global Scientific Publishing.
12. DreamBox Learning. (2024). DreamBox Learning: K–8 Math Program Overview. https://www.dreambox.com
13. Ejjami, R. (2024). The future of learning: AI-based curriculum development. International Journal for Multidisciplinary Research, 6(4), 1-31.
14. Feng, J., Yu, B., Tan, W. H., Dai, Z., & Li, Z. (2025). Key factors influencing educational technology adoption in higher education: A systematic review. PLOS Digital Health, 4(4), e0000764.
15. Fütterer, T., Hoch, E., & Dumont, H. (2024). Uncovering the Relationship Between Technology-Enhanced, Adaptive Teaching and Situational Interest in Mathematics in a Randomized Controlled Trial.
16. Goswami, A., & Sharma, A. (2024). AI for bridging socio-economic inequities in Indian education space. International Journal of Research and Scientific Innovation, XI (IV), 890-935.
17. Gradescope. (2023). Gradescope: AI-assisted grading platform. https://www.gradescope.com
18. Hwang, G. J., & Tu, Y. F. (2021). Roles and research trends of artificial intelligence in mathematics education: A bibliometric mapping analysis and systematic review. Mathematics, 9(6), 584.
19. Idowu, E. (2024). Personalized Learning: Tailoring Instruction to Individual Student Needs.
20. Ion, M. (2024). Beyond the Classroom: Exploring Mathematics Engagement in Online Communities with Natural Language Processing (Doctoral dissertation).
21. Kayyali, M. (2024). Future possibilities and challenges of AI in education. In Transforming education with generative AI: Prompt engineering and synthetic content creation (pp. 118-137). IGI Global Scientific Publishing.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

22. Khan Academy. (2024). Khanmigo AI tutor. https://www.khanacademy.org
23. Liswaniso, M., & Mbale, J. (2024). Leveraging Cloud Computing and Artificial Intelligence to Enhance E-Government Services in Developing Countries: Insights from Zambia. In Proceedings of International Conference for ICT (ICICT)-Zambia (Vol. 6, No. 1, pp. 39-44).
24. Lourenço, J., de Morais, J. P., Paulo, J. B., & Lucas, C. (2025). Artificial Intelligence as a Diagnostic Tool In Education: Enhancing Personalization and Learning Outcomes. In Edulearn25 Proceedings (pp. 9354-9361). IATED.
25. Mehmood, W., Gondal, S., Faiz, M. S., & Khurshid, A. (2025). AI-Assisted Metacognitive Strategies for Improving Self-Regulated Learning among High School Students. The Critical Review of Social Sciences Studies, 3(2), 2333-2349.
26. Meinel, C., Friedrichsen, M., Staubitz, T., Reinhard, S., & Köhler, D. (2024). Assessment Methods for Online Teaching. Scientific Reports of the German University of Digital Science, 3.
27. Meylani, R. (2024). Artificial Intelligence in Mathematics Teacher Education: A Systematic Review and Qualitative Synthesis of Contemporary Research Literature. International journal of Technology in Education Science, 1(1), 63-91.
28. Okonkwo, C. W., & Ade-Ibijola, A. (2021). Chatbots applications in education: A systematic review. Computers and Education: Artificial Intelligence, 2, 100033.
29. 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), em2478
30. Özcan Şahin, E., & Özçakır Sümen, Ö. (2025). Using Matific digital games to enhance second-grade students' conceptual understandings of multiplication. The Journal of Educational Research, 1-17.
31. Photomath. (2023). Photomath app description. https://photomath.com/en/
32. Prodigy Education. (2024). Prodigy Math Game overview. https://www.prodigygame.com
33. Ricci, F. Z., Medina, C. M., & Dogucu, M. (2023). Automated grading workflows for providing personalized feedback to open-ended data science assignments. arXiv preprint arXiv:2309.12924.
34. Sharma, P. (2024). Revolutionizing Math Education: The Power of Personalized Learning. Online Submission.
35. Shen, F. X., Wolf, S. M., Lawrenz, F., Comeau, D. S., Dzirasa, K., Evans, B. J., ... & Garwood, M. (2024). Ethical, legal, and policy challenges in field-based neuroimaging research using emerging portable MRI technologies: guidance for investigators and for oversight. Journal of Law and the Biosciences, 11(1), lsae008.
36. Song, X., Mak, J., & Chen, H. (2025). Teachers and Learners' Perceptions about Implementation of AI Tools in Elementary Mathematics Classes. SAGE Open, 15(2), 21582440251334545.
37. Swargiary, K. (2024). Teaching the Future. EdTech Research Association, US.
38. Tang, W. K. W. (2025). Artificial Intelligence in Mathematics Education: Trends, Challenges, and Opportunities. International Journal of Research in Mathematics Education, 3(1), 75-90.
39. Tlili, A., Saqer, K., Salha, S., & Huang, R. (2025). Investigating the effect of artificial intelligence in education (AIEd) on learning achievement: A meta-analysis and research synthesis. Information Development, 02666669241304407.
40. Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. Expert Systems with Applications, 252, 124167.
41. Xu, W., & Ouyang, F. (2022). The application of AI technologies in STEM education: a systematic review from 2011 to 2021. International Journal of STEM Education, 9(1), 59.
42. Xu, Z. (2024). AI in education: Enhancing learning experiences and student outcomes. Applied and Computational Engineering, 51(1), 104-111.
43. Yadav, D. S. (2024). Navigating the landscape of AI integration in education: opportunities, challenges, and ethical considerations for harnessing the potential of artificial intelligence (AI) for teaching and learning. BSSS Journal of Computer, 15(1), 38-48.
44. Yang, E., & Beil, C. (2024). Ensuring data privacy in AI/ML implementation. New Directions for Higher Education, 2024(207), 63-78.
45. Zou, D., Xie, H., & Kohnke, L. (2025). Navigating the Future: Establishing a Framework for Educators' Pedagogic Artificial Intelligence Competence. European Journal of Education, 60(2), e70117.