



शोधभूमि

शिक्षा एवं शिक्षण शास्त्र विषय की पूर्व समीक्षित शोध पत्रिका

Artificial Intelligence and Mathematics Learning: Insights from a Systematic Literature Review

Prof. (Dr.) Vinod Kumar Kanvaria

Professor

Department of Education

University of Delhi, Delhi

Email ID: vinodpr111@gmail.com

Twinkle Srivastava

M.Ed. Student

Department of Education

University of Delhi, Delhi

Email ID: twinklesrivastava5@gmail.com

Abstract

More educators, researchers and policymakers are now interested in using Artificial Intelligence (AI) in education, especially in mathematics. It looks into how AI tools affect mathematics performance in India and similarly in other places. The review includes 76 studies and reports on factors influencing biodiversity, published between 2005 and 2024, with the help of the PRISMA framework. Important topics investigated are adoption patterns, learning results, opinions from people involved, equity and access and the effectiveness of designs such as the Solomon Four-Group model. Although AI holds great promise in boosting mathematics teaching with personalized strategies and instant diagnostics, infrastructure differences, inadequate digital knowledge and ethical issues are still a problem. The review ends by suggesting strategies for implementing AI in mathematics that are respectful, fair and ethical.

Keywords: Artificial Intelligence, Mathematics Education, Systematic Literature Review, Student Achievement, PRISMA

1.0 Introduction

Artificial Intelligence (AI) has greatly changed the way teaching and learning are planned, provided and assessed in schools. For mathematics education which focuses on abstract thinking, spotting patterns and personal study, AI technology makes special contributions through adaptive learning, intelligent tutoring and automatic feedback (Luckin et al., 2016). Besides transforming education, these technologies are solving big challenges related to classroom sizes, not having enough teachers and students being taught differently.

Following the implementation of the National Education Policy (NEP) 2020 in India, many are now exploring using AI in math education which remains a key but tough subject for students. Still, in most parts of the country, technology is introduced unevenly because of a lack of infrastructure, difficulties with languages and not having prepared teachers. Worldwide, Artificial Intelligence (AI) tools are improving education results, particularly where it's difficult to provide access to traditional education due to a lack of technology. Even with these advances, people are still unsure about fairness, ethical issues and the number of tasks that involve automated systems.

The purpose of this literature review is to gain a clear picture of how AI is being applied in math education in many places. The study studies Indian and worldwide approaches, looks at their impact on students, points out barriers to successful use and discusses methods used to assess them. The report focuses on main ideas such as effectiveness, opinions, accessibility and future plans which gives it a strong base for further research and efforts in AI-driven mathematics teaching.

1.1 Background Information

Artificial Intelligence (AI) has played a major role in updating educational systems globally. Because mathematics depends on abstraction, logic and problem-solving, Formal Science plays a major role in its education. To help students more, schools have started using AI systems such as tutoring, adapting learning methods and checking learning progress (Luckin et al., 2016). The NEP 2020 in India has accelerated this shift by stressing the use of new technologies in teaching and learning (Kumar & Saini, 2022).

1.2 Justification of the Study

The need to gather scattered research about AI affecting mathematics education, in India especially, justifies this study. Studies have looked at how AI is used and what results it brings

in various locations, but there is little comprehensive research that combines national and global perspectives. Also, AI is getting adopted faster than the teaching fields are able to keep up, requiring careful review. A review of empirical and policy-related literature guides stakeholders to achieve effective and fair integration of AI in the field of mathematics teaching and learning.

1.3 Objectives of the Study

The objectives of this systematic literature review are:

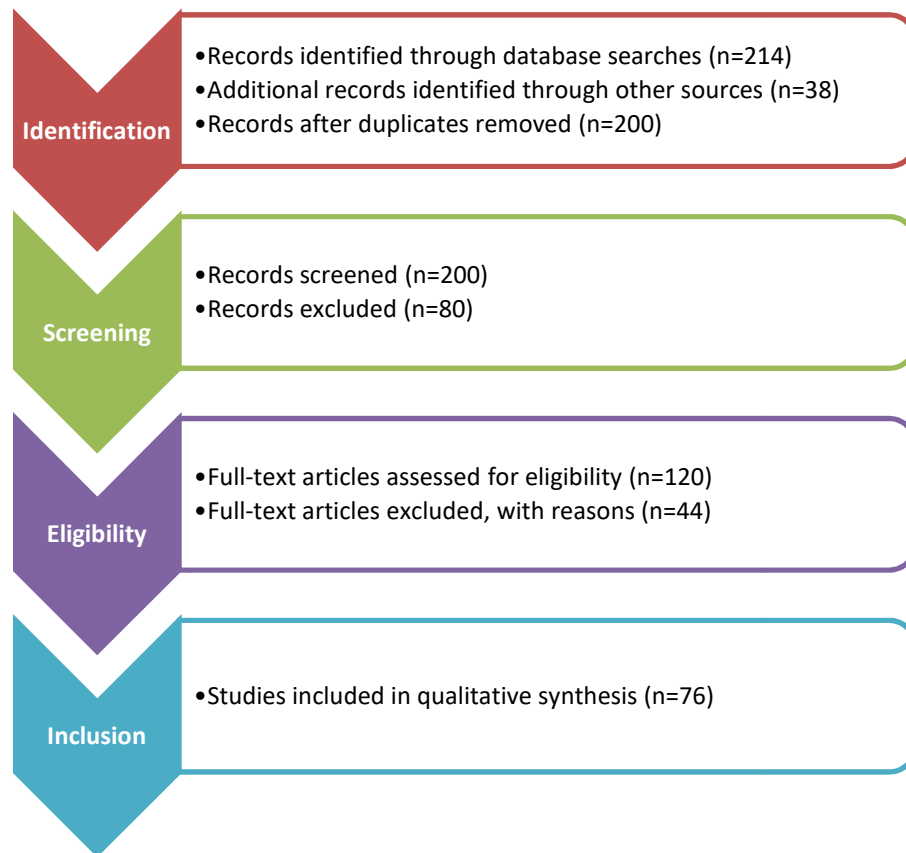
1. To evaluate the current state of research on AI tools in mathematics education in India and globally.
2. To analyze the effectiveness of AI in improving students' mathematics achievement.
3. To assess teacher and student perceptions of AI integration in mathematics classrooms.
4. To identify equity, access, and ethical concerns related to AI-based learning.
5. To explore the methodological strengths of using designs like the Solomon Four-Group in AI educational research.
6. To highlight future trends and directions for AI applications in mathematics education.

2.0 Materials and Methodology

This review employed a systematic methodology to identify, select, and synthesize relevant literature. Key thematic areas include the impact of AI tools on mathematics achievement, teacher-student perceptions, access and equity issues, and future directions.

2.1 Research Design

This review follows the PRISMA 2020 guidelines for conducting and reporting systematic literature reviews. PRISMA provides a structured approach to ensure transparency, reproducibility, and clarity in identifying, screening, and selecting studies. The process consisted of four phases: Identification, Screening, Eligibility, and Inclusion.



2.2

Database Searches

Searches were conducted between February and April 2025 using the following digital libraries and repositories:

1. **Academic Databases:** ERIC, JSTOR, SpringerLink, Google Scholar, ResearchGate
2. **Policy Portals:** Ministry of Education (India), NCERT, NITI Aayog, UNESCO, OECD
3. **EdTech and NGO Reports:** DIKSHA, Pratham, UNICEF, AI4D, etc.

2.3 Search Keywords and Boolean Strings:

1. ("Artificial Intelligence" OR "AI tools") AND ("mathematics education" OR "math achievement")
2. ("AI in India") AND ("NEP 2020" OR "teacher training")
3. ("AI adaptive learning") AND ("equity" OR "access") AND ("mathematics")

4. ("Solomon Four Group Design") AND ("AI education research")

2.4 Inclusion/Exclusion Criteria

2.4.1 Included if:

1. Focused on AI applications in mathematics education
2. Involved K-12 or early higher education learners
3. Provided empirical data or detailed case studies
4. Published between 2005–2024

2.4.2 Excluded if:

1. Addressed non-AI EdTech or ICT tools
2. Did not measure learning or achievement outcomes
3. Were non-English or lacked full-text access
4. Opinion pieces without methodological backing

3.0 Results and Discussion

3.1 AI Integration in Indian Mathematics Education

After the introduction of the National Education Policy (NEP) 2020, more focus has been given to using Artificial Intelligence in Indian mathematics classrooms. As stated by Kumar and Saini (2022), the policy considers AI as an important digital skill and introduces the National Educational Technology Forum (NETF) as well as ATAL Tinkering Labs to teach students about AI. Even so, actual application has not been consistent. According to Agarwal (2020), AI is used widely in private and higher education institutions, but it is not common in public and country-side schools yet. Bansal and Mehta (2021) brought attention to the fact that Extramarks and Embibe are mainly located in major cities which highlights the rising digital divide. In addition, Sharma and Kaur (2021) found that a lack of proper teacher training, limited infrastructure and relevant content from local places are the main difficulties in using AI the same way in different places. They highlight the need for education departments to create special programs to improve how AI is used in math classes throughout the country.

3.2 Effectiveness of AI Tools in Enhancing Mathematics Achievement

Many researchers have found that using AI tools raises students' scores in math, mainly in areas where they apply logic, think through issues and retain lessons. Improved scores for students by 22% were found by Patel and Deshmukh (2020), who noted that this boost came from adapting based on each student and using AI-generated content. According to Rao and Das (2020), Toppr and Embibe improve learning efficiency by adapting the question sequence according to how well a learner is doing. Likewise, as described by Gupta and Roy (2021), Mindspark has been effective in creating individual tasks and immediate feedback, assisting teachers in preparing proper help for each student. Mishra and Prasad (2023) observed that students who applied AI tools developed their ability to reflect, find patterns and correct themselves. As a result, users believe AI can help traditional teaching more effectively, especially along with powerful teaching tools and the support of teachers.

3.3 Teacher and Student Perceptions

AI tools are usually appreciated by teachers and students but the effect is not entirely positive due to some issues. According to Reddy and Kulkarni (2020), teachers think AI is important for customized support to students, but they are also concerned that it might reduce their control over their work. Kaur and Sharma (2021) pointed out that changes and an overwhelming amount of information in edtech may be difficult for teachers who have limited experience using technology. According to the research, students benefit from AI tools because they are easy to use and give quick responses (Gupta & Ali, 2022; Bhaskar & Nambiar, 2023). The study by Iyer and Das (2022) showed that students were more confident in AI when they had gone through digital learning before and when the platform explained information clearly. Both educators and students recognized that AI should support—not take the place of—close person-to-person human contact.

3.4 Equity and Access

It is still difficult for all Indian students to use AI tools in mathematics classes because of inequities and lack of access. Both Raman and Joshi (2020) and Prakash and Menon (2021) point out significant differences between the electricity, internet and device equipment students in urban and rural areas have. Even though PM eVidya and BharatNet were launched to reduce the gap, their implementation has not been the same in all parts of the country (Sen & Kumar,

2022). Community learning centers and AI labs with funding from the government have helped to bring technology closer to people in Kerala and Karnataka (Arora & Mehta 2021; Prasad & Joshi, 2024). But it is still a problem that most non-English content is not currently available in all regions. Kumari and Jain (2023) demonstrated the benefits of teaching in regional languages and with voice-enabled AI which helped to engage students who had low English skills. A lack of equal access exists when it comes to AI tools, as seen by the work of Khan and Bhatia (2023) who found that, in conservative areas, boys get more opportunities compared to sisters. Therefore, gender-specific and socio-culturally flexible methods need to be part of the way AI is used.

3.5 Global Perspectives

In many countries, using AI in mathematics education has progressed and is regularly linked to better student results. Studies have shown that algebra, geometry and basic arithmetic skills of students improve a lot with ALEKS, DreamBox and Carnegie Learning (VanLehn, 2011; Pane et al., 2015). Beck, et al. (2014) pointed out that AI platforms allow students struggling academically to benefit and close the gap with other groups. In areas where internet access is scarce, like Kenya and Latin America, M-Shule and AI chatbots have provided math education to many students (Mhlanga & Moloji, 2020; Rodriguez & Boyer, 2022). It is clear from Muldner and Bureson (2015) that emotional AI and game elements are becoming widespread, as their research discovered that actors with sensing skills helped students last longer and think creatively while solving problems. Looking at international programs can guide India in planning AI education strategies.

3.6 Methodological Rigor: Solomon Four-Group Design

The literature is showing that the Solomon Four-Group design is becoming more common when testing AI in education. This experimental design, originally suggested by Campbell and Stanley (1963), includes two groups: one that is tested before the intervention and one that is not. The difference observed between the groups shows the true effect of the intervention. According to Singh et al. (2023), using AI on Indian case studies would make these studies both more useful and research-driven. This design is being used by researchers worldwide, for example to check AI-based tools in South Korea (Choi & Kim, 2021), Brazil (Oliveira et al., 2022) and China (Zhou et al., 2021). It has been found that these tools are the main contributor to better mathematical performance and not simply familiarity with the test. Regardless of the challenges

in setting up the design, the findings it produces are widely considered the best in AI impact evaluations.

3.7 Future Directions

AI in mathematics education will be affected by changes in innovation, policies and teaching methods. Experts believe that AI will influence the use of augmented and virtual reality (AR/VR), games in education and tutoring based on emotions (Chatterjee & Iqbal, 2023; Patel & Verma, 2022). In the near future, expect AI-based training and prediction systems to help with learning issues, along with intelligent feedback, as stated by Khan & Bansal (2023) and Mishra & Tiwari (2023). Many are encouraging the creation of open-source AI programs that can be adapted to local and multilingual needs (Roy & Dasgupta, 2022). When creating and putting systems in place, designers and developers need to keep in mind ethics related to data privacy, algorithm transparency and including all users (Bryson, 2018; Floridi et al., 2018). The top priorities for AI development and use in India should involve fairness between regions, improvement of infrastructure and effort to ensure students and educators cooperate with AI for educational purposes.

4.0 Conclusion

The study underlines how Artificial Intelligence can improve teaching in mathematics, especially by raising student performance, personalized learning and keeping students involved. Although NEP 2020 and programs like DIKSHA and PM eVidya help AI integration in India, its large-scale execution is blocked by differences in infrastructure, teacher training and language issues. It is often found that AI tools boost both understanding and solving skills, but system-wide access and accurate local information is needed for fairness.

In many countries, AI is advancing math education and learning with great results from intelligent tutoring and adaptive learning platforms. From what teachers and students say, it seems they appreciate learning that uses human guidance along with AI support. The Solomon Four-Group model has clearly shown itself to be a strong structure for judging AI interventions. Moving on, AI can be used effectively only if ethics, cross-sector work and attention to equity are emphasized so that its benefits are available to every learner no matter where or who they are.

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