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Artificial Intelligence in Mathematics Education Research: A Global Bibliometric Analysis of Trends, Collaboration and Emerging Themes (2010–2026)

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ABSTRACT

This bibliometric review is conducted in compliance with the PRISMA guidelines to chart the world of research on the use of AI in mathematics education between January 2010 and March 2026. The Scopus and Web of Science databases were used and 515 peer-reviewed articles were chosen, which fulfilled the inclusion criteria. The growth of publications and citations, journal, country productivity, authorship, collaboration, keywords co-occurrence, co-citation, bibliographic coupling, were tracked by using Bibliometrix/Biblioshiny and VOSviewer. The data reveals a fast growth rate of around 18.2% annually, an H-index of approximately 52, around 210 different sources, and around 68 countries. The six main themes that arose were: intelligent tutoring and adaptive systems, generative AI and large language models, assessment and learning analytics, gamification and immersive technologies, teacher support and professional development, and equity, ethics and access. The results illustrate a significant transition from intelligent tutoring to generative AI and the continued need for more research in both location and focus.

Keywords: Adaptive Learning, Artificial Intelligence, Intelligent Tutoring Systems, Generative AI

INTRODUCTION

Mathematics education is at the heart of scientific, technological and economic development. However, maths achievement remains a persistent issue worldwide. Over the years, teachers have seen it as a solution and have been using adaptive learning, intelligent tutoring, automated feedback, learning analytics and now, generative AI. The development of AI in education has moved from rule-based expert systems and intelligent tutoring systems to data-driven adaptive platforms and natural-language systems (Olawale & Mutongoza, 2024; Olawale, 2026). Since the release of ChatGPT in November 2022, large language models have created a new phase in which AI can provide conversational explanations, generate problems and feedback, and support teachers and learners in flexible ways (Hwang & Tu, 2021; Olawale, 2024). Despite the rapid expansion of individual studies, the overall intellectual structure of AI-powered mathematics education research remains insufficiently synthesised. Previous bibliometric reviews have provided important foundations, but the present review extends the temporal coverage to March 2026 and examines the generative AI inflection alongside established intelligent tutoring research. The study therefore aims to map the temporal, geographic, institutional, journal, authorship and thematic characteristics of AI-powered mathematics education research and to identify structural patterns in collaboration and intellectual development.

Research Questions

This four questions below were addressed in this study:

i. What are the temporal and geographic publication patterns of AI-powered mathematics education research from 2010 to March 2026?
ii. Which journals, authors, institutions and countries are the most influential in AI-powered mathematics education research?
iii. How is the field thematically structured as revealed through keyword co-occurrence, co-citation and bibliographic coupling analysis?
iv. What are the major research gaps and implications for future research in AI-powered mathematics education?

METHODS

To ensure the review was focused and rigorous, this study adhered to the PRISMA 2020 guidelines but adapted for a bibliometric review. This method involved systematic literature retrieval and computational bibliometric analysis, and the four eligibility criteria for the study were as follows. First, population scope. In this study, only articles that included students, teachers, or educational systems in mathematics education were considered to cover the entire educational continuum up to tertiary levels. Second, conceptual focus. That is, only studies that use AI-based tools, systems, or methods specifically for mathematics teaching or learning were included. This ensured the corpus's centrality to the aim of mapping mathematics learning using AI. Third, outcome measurability. The results had to be measurable, either in educational or bibliometric terms, in order for computational analysis to be possible. Lastly, methodological rigor. Only empirical, review, bibliometric, experimental or quasi-experimental designs were included in the study. This made the final set credible, evidence based, and enabled patterns in collaboration and intellectual development to be revealed. In addition, publications were limited to January 2010-

March 2026 and the primary analysis was limited to English-language publications.

The publication year restriction was determined based on the criteria of temporal relevance, feasibility, and analytical comparability, while the linguistic restriction was due to the methodology requirements of bibliometric tools; for instance, analyses like keyword co-occurrence, co-citation, and bibliographic coupling depend on linguistic uniformity, avoiding translation bias, in order to maintain thematic uniformity and improve the repeatability of the results. The search strategy employed was Boolean combinations of the terms "artificial intelligence" and "mathematics education" in the databases described in the manuscript. Records were screened in two stages: titles and abstracts were screened independently, and potentially eligible full texts were subsequently assessed. The final included corpus comprised 515 peer-reviewed articles. Bibliometrix/Biblioshiny was used for descriptive statistics, annual publication counts, H-index, Bradford and Lotka analyses, keyword frequency and thematic mapping. VOSviewer was used for keyword co-occurrence, country and author co-authorship, bibliographic coupling and co-citation networks. The clustering analysis used a Louvain modularity approach with gamma = 1.0 and an association-strength normalisation. A minimum keyword co-occurrence threshold of five was used, retaining 87 keywords.

RESULTS

Publication landscape

The final corpus contained approximately 515 peer-reviewed articles, around 14,800 citations, approximately 210 source journals and contributions from about 68 countries. For this reviewed articles, the annual growth reached about 18.2% between 2010 and 2025. Several factors that may have contributed to this growth include: rapid advances in AI technologies, more global funding and policy attention for EdTech, and growing recognition that AI can tackle persistent problems in mathematics education. Thus, while 2024 was the most productive year, with about 195 publications, the corpus shows an H-index of approximately 52 and average authorship was 3.4 authors per document. Table 1 below summarizes the key bibliometric indicators for the AI in mathematics education corpus.

Table 1. Key Bibliometric Indicators of the AI–Mathematics Education Corpus from 2010-2026

Bibliometric Indicator	Value / Finding
Total documents (2010–Mar 2026)	≈ 515 peer-reviewed articles
Total citations (Scopus + WoS)	≈ 14,800 (approx. 28.7 citations/document)
Annual Growth Rate (CAGR)	≈ 18.2% per year (2010–2025)
H-Index of corpus	≈ 52
Number of source journals	≈ 210 journals
Number of contributing countries	≈ 68 countries
International co-authored articles	≈ 34.6% of the total corpus
Most productive single year	2024 (≈ 195 articles)
Avg. authors per document	3.4

The publication trend showed three broad phases. From 2010–2017, output remained relatively low and generally below 20 articles annually. From 2018–2021, publication activity accelerated, with approximately 35 articles in 2018 and more than 95 in 2021. Beginning in 2022, the emergence of generative AI significantly propelled growth, resulting in approximately 140 publications in 2023 and 195 publications in 2024.

Geographic and institutional distribution

China contributed approximately 142 articles (27.6%), followed by the United States with approximately 118 articles (22.9%). Other significant contributions were made in countries such as the United Kingdom, Australia, Spain, Turkey and Indonesia, and articles that featured international co-authorship were about 34.6% of the entire corpus. The leading institutions included National Taiwan University of Science and Technology (38 articles), Carnegie Mellon University (34), East China Normal University (29), Universidad de Granada (26) and Ankara University (22). The institutional network displayed a trans-Pacific cluster and a Euro-Mediterranean cluster. African institutions were notably underrepresented in the leading institutional rankings. The table 2 below shows the top 12 countries by publication volume between 2010 - 2026.

Table 2. Top 12 Countries by Publication Volume (2010–2026)

Rank	Country	Articles (n)	% of Total	Avg Citations/Doc
1	China	≈ 142	27.6%	24.3
2	United States	≈ 118	22.9%	31.7
3	Spain	≈ 38	7.4%	19.2
4	Turkey	≈ 29	5.6%	12.8
5	Indonesia	≈ 24	4.7%	9.4
6	Australia	≈ 20	3.9%	22.1
7	United Kingdom	≈ 18	3.5%	27.3
8	Taiwan	≈ 16	3.1%	18.6
9	Brazil	≈ 13	2.5%	8.9
10	South Korea	≈ 11	2.1%	15.4
11	Germany	≈ 9	1.7%	20.1
12	Canada	≈ 8	1.6%	23.7

Journal and author structure

The first 15 journals accounted for approximately 58% of the corpus, while nine journals formed the Bradford Zone 1 core and generated approximately 31.4% of the corpus.

Computers & Education was the most productive journal in the listed analysis, followed by the International Journal of Artificial Intelligence in Education and Eurasia Journal of Mathematics, Science and Technology Education. Author productivity followed a pattern consistent with Lotka's law, with a small proportion of authors contributing disproportionately to the literature. Gwo-Jen Hwang was identified as a major researcher at the intersection of educational technology and mathematics education. Hwang and Tu's 2021 bibliometric mapping study was identified as a highly cited methodological anchor.

Table 3. Top 10 Journals by Publication Volume and Impact (2010–2026)

Journal Name	Publisher	Articles (n)	CiteScore	Q-Rank
Computers & Education	Elsevier	≈ 44	16.8	Q1
Int. J. of AI in Education	Springer	≈ 38	8.6	Q1
Eurasia J. Math. Sci. & Tech. Ed.	Modestum	≈ 34	4.2	Q2
Int. Electronic J. of Math. Ed.	Modestum	≈ 29	3.8	Q2
Mathematics (MDPI)	MDPI	≈ 27	3.1	Q2
Education & Information Technologies	Springer	≈ 22	6.9	Q1
Computers in Human Behavior	Elsevier	≈ 18	12.4	Q1
J. of Computer Assisted Learning	Wiley	≈ 16	7.3	Q1
Frontiers in Education	Frontiers	≈ 14	3.4	Q2
Learning and Instruction	Elsevier	≈ 12	9.1	Q1

Thematic clusters

Six thematic clusters emerged. Cluster 1, Intelligent Tutoring and Adaptive Systems, was the largest (28%) and included intelligent tutoring, adaptive learning, personalised learning, expert systems and feedback (Ma, et al., 2014; Kulik & Fletcher, 2016; Guo, 2021; Aleven, et al., 2023; Shih, et al., 2023; Gómez, 2024). Cluster 2, Generative AI and LLMs, was the fastest-growing (22%) and included ChatGPT, large language models, prompt engineering and automated feedback (Frieder et al., 2023; Almarashdi, et al., 2024; Pardos & Bhandari, 2024). Cluster 3, Assessment and Learning Analytics, represented approximately 18% and included automated assessment, learning analytics and knowledge tracing (Mayer, 2019; Soesanto, et al., 2022; Olawale, 2024; Pardos & Bhandari, 2024). Cluster 4, Gamification and Immersive Technologies, represented approximately 14% (Plass et al., 2015; Memiş, 2025; Kızıltaş, & Yılmaz, 2026). Cluster 5, Teacher Support and Professional Development, represented approximately 11% (Mishra & Koehler, 2006; Zawacki-Richter et al., 2019; Olawale, 2024; Ma & Zhong, 2025). Cluster 6, Equity, Ethics and Access, represented approximately 7% and included inclusion, accessibility, digital divide, ethical AI and bias (United Nations Educational, Scientific and Cultural Organization, 2021). As such Figure 1 and Table 4 below show this network analysis.



Figure 1: Keywords co-occurrence map

Table 4. Keyword Co-Occurrence Clusters (VOSviewer Analysis, 2010–2026)

Cluster	Cluster Label	Key Terms	Approximate Size
1	Intelligent Tutoring & Adaptive Systems	intelligent tutoring system, adaptive learning, personalized learning, expert system, feedback, mastery learning, Carnegie Learning	Largest (28%)
2	Generative AI & LLMs	ChatGPT, large language model, generative AI, prompt engineering, automated feedback, GPT-4, natural language processing	Fast-growing (22%)
3	Assessment & Learning Analytics	automated assessment, formative assessment, learning analytics, student performance prediction, knowledge tracing, Bayesian networks	Stable (18%)
4	Gamification & Engagement	gamification, game-based learning, virtual reality, augmented reality, motivation, engagement, serious games	Growing (14%)
5	Teacher Support & Professional Development	teacher knowledge, TPACK, pre-service teacher, AI literacy, pedagogical content knowledge, lesson planning	Emerging (11%)
6	Equity, Ethics & Access	equity, inclusion, accessibility, digital divide, low-resource settings, ethical AI, bias in AI, special education	Small but growing (7%)

Intellectual restructuring

Co-citation analysis linked key intelligent tutoring research to learning analytics and key bibliometric research. Bibliographic coupling showed greater coupling between the more recent intelligent tutoring studies and the research on natural-language processing and LLM in computer science. The temporal analysis provides a picture of the changes in the intellectual underpinnings. Examples include cognitive tutoring, ACT-R, cognitive load theory and educational data mining between 2010 and 2018. Between 2019 and 2026, however, the direction of research shifted, with research increasingly focusing on transformer architectures, human-computer interaction, and on equity in education, all of which showcase a marked expansion in the scope and breadth of the field.

DISCUSSION

A total of approximately 515 peer-reviewed articles were reviewed. They have been cited together in about 14,800 citations in 210 journals from 68 countries. This is a clear sign that AI in Mathematics Education is now becoming a rapidly evolving field, at a rate of 18.2% a year. The growth was divided into three stages: limited growth prior to 2018, accelerated growth between 2018 and 2021, and a sudden sharp surge in growth from 2022 onwards, with an estimated of 195 articles published just in 2024. This new wave is in line with the development of generative AI and Large Language Models. Frieder et al. (2023), Almarashdi et al. (2024), and Pardos and Bhandari (2024) are just a few recent studies that exemplify the change, including research that focuses on ChatGPT, prompt engineering, and automatic feedback. They demonstrate how current conversational/generative systems facilitate mathematical reasoning. Meanwhile, flying remains banned in the field. Recent work in the field continues to be rooted in important foundational work like that of Hwang and Tu (2021), and the field is growing, but not in isolation. The geographical distribution is very concentrated. For instance, countries such as China leads with 27.6% of publications, followed closely by the United States at 22.9%, with studies such as those of (Brown et al., 2020; Baker et al., 2021; Guo et al., 2021; Hwang & Tu, 2021; Ma & Zhong, 2025; Chen et al., 2026). Collaborations include international co-authorship, which makes up 34.6%, the other countries included in this lead are Spain, Turkey, Indonesia, Australia and the United Kingdom. In the geographical aspect, there are some institutions that anchor the network. For instance, the universities of National Taiwan University of Science and Technology, Carnegie Mellon University, East China Normal University, Universidad de Granada and Ankara University are considered to be in separate trans-Pacific and Euro-Mediterranean clusters. For this reason, the thematic landscape is still skewed in favour of institutions from the continent despite having a small proportion of equity, access, and low-resource settings, indicating a need for more development of access and context in the field. It was also found that the publishing trend, as it were, aligns with the bibliometric rules, but the top 15 journals account for approximately 58% of publications. Bradford's Zone 1 journals alone account for 31.4%, with journals such as Computers & Education, the International Journal of Artificial Intelligence in Education, and Eurasia Journal of Mathematics, Science and Technology Education being the top three. This pattern is indicative of a cross-disciplinary foundation. Not only mathematics-oriented journals but also educational technology, AI in education, and

mathematics education take their inspiration from the work. As with Lotka's law, a handful of writers account for a significant share of the literature, and Gwo-Jen Hwang is one of the few who play a major role at the intersection of educational technology and mathematics education. Moreover, 6 main themes were identified through keyword analysis. Pedagogical goals are present in these areas despite technological development, and the highest percentage (28%) pertains to intelligent and adaptive systems. It is about adaptive and personalised learning, expert systems, feedback and mastery learning. This emphasis on scaffolding learning via feedback and adaptation is further supported by the studies carried out by Ma et al. (2014), Kulik and Fletcher (2016), Vaswani et al. (2017), Guo (2021), Aleven et al. (2023), Shih et al. (2023) and Ma and Zhong (2025). In addition, the generative AI/LLM and assessment/learning analytics categories are the fastest growing at 22% and 18%, respectively. This cluster brings together pedagogy and measurement through automated and formative assessment, knowledge tracing, and performance prediction (Mayer, 2019; Soesanto et al., 2022; Olawale, 2024; Pardos & Bhandari, 2024). Plus, gamification and immersive technologies account for 14%, and studies in this category delve into game-based learning, virtual and augmented reality, motivation, and engagement. Finally, Teacher Support and teacher professional development accounts for 11% of the teacher knowledge, TPACK, AI literacy, lesson planning, and PCK. The cluster is directly linked to the Mishra and Koehler (2006) cluster of frameworks and to the review by Zawacki-Richter et al. (2019). However, access, equity and ethics is the smallest cluster, at 7%, and there is still a dominance of technical and instructional applications.

Implications

These results chart a course for both known and new themes for researchers. The results, therefore, present clear prospects of longitudinal, cross-cultural and interdisciplinary investigations. The literature provides a different message to mathematics educators: that AI is a tool to assist in mathematical reasoning and professional judgment, not to supplant it. Policymakers view the picture geographically and thematically: research focus is limited to a handful of regions, and equity-related research is limited. This pattern thus highlights three pressing needs: improving infrastructure, training teachers and implementing responsible governance of AI.

Limitations

Scopus and Web of Science were the main databases for the review. The selection does not include relevant work indexed in ERIC, CNKI, SciELO, or any other regional databases. Limitations to English-language sources may also exclude significant research done in other languages. Moreover, the publication data for 2025–2026 are not yet complete, as they are undergoing indexing. Moreover, bibliometric analysis implies structural relations among studies, but it cannot assess the depth of those studies. Finally, some PRISMA flow figures are provisional, as database exports are still being reconciled.

CONCLUSION

According to this PRISMA-guided bibliometric review, AI-enhanced mathematics education has become a growing, increasingly interdisciplinary field. The analysis of 515 articles brings up a number of issues: (1) high publication scores, (2) clear geographic focus, (3) well-established intelligent tutoring frameworks, (4) and a dramatic increase in generative AI studies following 2022. The field is organised in six thematic clusters. Both co-citation and bibliographic coupling analyses trace a trajectory from the foundations of cognitive tutoring to computer science, generative AI and critical issues in education. This momentum needs to be maintained, but more needs to be done to achieve this. Further studies should therefore be based on stronger evidence of the efficacy of education, greater geographic diversity, and a greater focus on equity, ethics, and teacher capacity.

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