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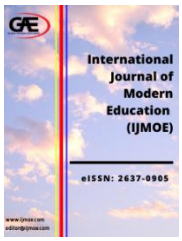

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A BIBLIOMETRIC PERSPECTIVE ON STUDENT MOTIVATION AND INTEREST IN MATHEMATICS

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Abstract:

This study presents a bibliometric perspective on student motivation and interest in mathematics, aiming to map the intellectual structure, research trends, and collaborative networks in this domain. Motivation and interest have long been recognized as crucial factors in shaping students' mathematical learning outcomes. Yet, the fragmented nature of the literature often limits a comprehensive understanding of their development. To address this gap, bibliometric techniques were employed using a dataset of 993 publications retrieved from Scopus through an advanced search with the keywords "mathematics," "student," and "motivation." The analysis followed a systematic approach: first, data collection from Scopus ensured coverage of peer-reviewed studies across multiple disciplines; second, Scopus Analyzer was applied to generate statistical insights and graphical representations of publication trends, citation patterns, and authorship distribution; third, OpenRefine was used to clean, refine, and harmonize inconsistencies in the dataset; and finally, VOSviewer software facilitated the visualization of keyword co-occurrence, co-authorship by country, and thematic clustering. The results revealed that research productivity has shown steady growth, with notable peaks in the last five years, reflecting increasing attention to motivational factors in mathematics education. The most cited contributions were strongly connected to active learning, student engagement, and the integration of digital technologies in mathematics learning. Furthermore, co-occurrence analysis identified six major clusters, representing themes such as learning systems, problem-solving approaches, mathematics anxiety, technology-enhanced learning, and psychological constructs like self-efficacy and metacognition. Collaboration networks showed that the United States, China, and Indonesia emerged as leading contributors, with diverse international partnerships shaping the global research landscape. This study

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contributes to the body of knowledge by providing an evidence-based overview of research dynamics in student motivation and interest in mathematics, offering valuable insights for educators, researchers, and policymakers to strengthen student-centred learning and foster innovation in mathematics education.

Keywords:

Mathematics, Students, Motivation

Introduction

Understanding student motivation and interest in mathematics is crucial for enhancing educational outcomes and fostering a positive attitude towards the subject. Mathematics is often perceived as a challenging and abstract discipline, which can lead to varying levels of student engagement and achievement. This paper aims to explore the factors influencing student motivation and interest in mathematics, examining both intrinsic and extrinsic motivators, as well as the role of educational environments and teaching strategies. By synthesizing recent research, this study seeks to provide a comprehensive perspective on how to cultivate a sustained interest in mathematics among students.

Research indicates that a complex interplay of factors, including technology integration, collaborative learning, and student confidence, influences student motivation and interest in mathematics. A study involving senior high school students in Kumasi found that technology integration and collaborative learning had a significant positive effect on academic achievement in mathematics, although student motivation alone did not directly impact achievement (Boadu & Boateng, 2024). This suggests that while motivation is essential, it may need to be supported by other educational strategies to effectively enhance student performance.

The role of mindset and inclusivity in informal STEM programs has also been highlighted as critical for sustaining math motivation. A longitudinal study in the UK and the US revealed that a growth mindset positively influenced students' utility values in mathematics, while a fixed mindset had a negative impact. Additionally, perceptions of inclusivity at informal STEM sites were found to positively affect initial levels of utility, particularly for girls and older adolescents (Ozturk et al., 2024). These findings underscore the importance of fostering an inclusive and growth-oriented learning environment to maintain student interest in mathematics.

Gender differences and the impact of school type on student interest in mathematics have been explored in various contexts. During the COVID-19 pandemic, a study in Indonesia found that female students exhibited higher interest in mathematics compared to their male counterparts, and public school students showed greater interest than those in private schools (Marchy et al., 2023). This highlights the need to consider demographic factors when designing interventions to boost student motivation in mathematics.

Teacher enthusiasm and classroom environment also play a significant role in shaping student interest in mathematics. Research involving students and teachers in grades 3 to 10 demonstrated that students' perceptions of their teachers' enthusiasm positively predicted their

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interest in mathematics. However, at the class level, teachers' enthusiasm for the subject negatively impacted students' emotional interest, suggesting a nuanced relationship between teacher behaviour and student motivation (Carmichael et al., 2017). This indicates that while teacher enthusiasm is generally beneficial, it must be balanced with strategies that directly engage students emotionally and cognitively.

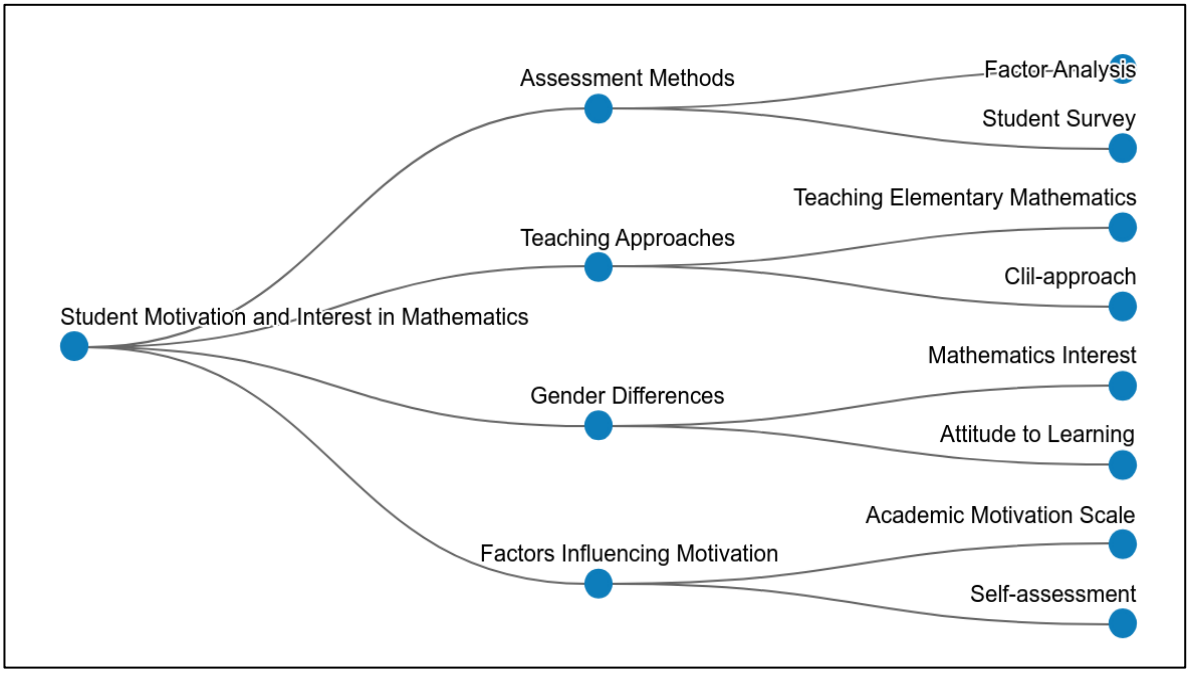

Figure 1: Concept Map of Perspective on Student Motivation And Interest In Mathematics

Source: (Scopus AI, Fri Oct 03 2025)

Figure 1 illustrates the interconnected themes surrounding student motivation and interest in mathematics from a bibliometric perspective. The analysis highlights four major clusters: assessment methods, teaching approaches, gender differences, and factors influencing motivation. Within assessment methods, studies emphasize the role of factor analysis and student surveys in measuring student engagement and learning outcomes. Teaching approaches are strongly tied to innovations, such as teaching elementary mathematics and the Content and Language Integrated Learning (CLIL) approach, suggesting that pedagogical strategies directly influence students' interest in mathematics. Gender differences emerge as a notable factor, linking to attitudes toward learning and varying levels of mathematics interest across student groups. Additionally, broader factors influencing motivation include the use of academic motivation scales and self-assessment practices, which provide insight into individual learners' intrinsic and extrinsic drivers. Collectively, the bibliometric mapping indicates that motivation and interest in mathematics are shaped not only by teaching and assessment strategies but also by student characteristics and contextual factors. This synthesis underscores the importance of adopting multidimensional strategies that integrate assessment, pedagogy, and student-centred approaches to enhance mathematics learning and sustain long-term engagement across diverse learners.

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In conclusion, student motivation and interest in mathematics are multifaceted constructs influenced by a variety of factors, including educational strategies, mindset, inclusivity, gender, school type, and teacher enthusiasm. Effective interventions to enhance student motivation in mathematics should consider these diverse influences and aim to create a supportive, inclusive, and engaging learning environment. Future research should continue to explore these relationships, particularly in cross-cultural contexts, to develop a more comprehensive understanding of how to foster a sustained interest in mathematics among students.

Research Question

RQ 1: What are the research trends in these studies based on the year of publication?
RQ 2: What are the most cited articles?
RQ 3: Where are the top 10 countries relying on the number of publications?
RQ 4: What are the popular keywords related to the study?
RQ 5: What are the patterns of co-authorship based on countries' collaboration?

Methodology

Bibliometrics represents a rigorous methodological approach dedicated to systematically gathering, organizing, and analyzing bibliographic data from scientific publications (Alves et al., 2021; Assyakur & Rosa, 2022; Verbeek et al., 2002). Apart from fundamental statistical indicators like determining the journals of publication (Wu & Wu, 2017), bibliometric studies increasingly employ advanced techniques, for example, document co-citation analysis to reveal intellectual structures and research networks within a field. Performing an efficient literature review requires a thorough and iterative process that includes choosing suitable keywords, systematically searching the literature as well as performing in-depth analysis to ensure a detailed bibliography and produce reliable findings (Fahimnia et al., 2015). In line with this, the present study concentrates on high-impact publications, as these offer essential perspectives into the theoretical frameworks that underpin and shape the evolution of the research domain. In ensuring data accuracy and reliability, SCOPUS was chosen as the primary source of database specifically caused by its comprehensive coverage of peer-reviewed academic outputs (Al-Khoury et al., 2022; di Stefano et al., 2010; Khiste & Paithankar, 2017). In maintaining quality standards, selection was restricted to only articles published in peer-reviewed academic journals, while books, lecture notes, and other non-scholarly sources were deliberately excluded (Gu et al., 2019). Note that the dataset comprised publications from 2015 to October 2025, retrieved exclusively from Elsevier's Scopus, providing a robust foundation for further bibliometric analysis.

Data Search Strategy

To collect strategic data for this study, an advanced search was performed in the Scopus database in October 2025. The search query applied was TITLE (("mathematics" OR "mathematic" OR "math") AND ("motivation" OR "interest" OR "learning") AND student) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Mathematics") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Learning") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Education") OR LIMIT-TO (EXACTKEYWORD , "Teaching") OR LIMIT-TO (EXACTKEYWORD , "Motivation") OR LIMIT-TO (EXACTKEYWORD , "Learning Mathematics")). This search string was carefully formulated to capture highly relevant publications focusing on student motivation, interest, and learning in mathematics education. In ensuring the quality and relevance of the

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retrieved literature, specific screening criteria were applied as outlined in Table 1. Only publications written in English were included, while all non-English studies were excluded. Furthermore, the timeline was restricted to works published between 2015 and 2025, thus excluding older studies to concentrate on more recent and up-to-date research contributions. After applying these criteria, the final dataset comprised 993 documents, as summarized in Table 2. This refined dataset offers a robust and thematically coherent foundation for bibliometric and content analysis, ensuring both breadth and depth in exploring the research field. By narrowing the scope to title-based searches, applying strict inclusion and exclusion parameters, and filtering through specific keywords, the dataset reflects a reliable body of literature. This rigorous methodology enhances the validity of the study and provides meaningful insights into research trends, collaborative patterns, and emerging themes in the intersection of student motivation, interest, and mathematics education.

Table 1: The Search String

Scopus	**TITLE (("mathematics" OR "mathematic" OR "math") AND ("motivation" OR "interest" OR "learning") AND student) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Students") OR LIMIT-TO (EXACTKEYWORD , "Mathematics") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Learning") OR LIMIT-TO (EXACTKEYWORD , "Mathematics Education") OR LIMIT-TO (EXACTKEYWORD , "Teaching") OR LIMIT-TO (EXACTKEYWORD , "Motivation") OR LIMIT-TO (EXACTKEYWORD , "Learning Mathematics"))** **access date: October 2025**

Source: (Scopus AI, Fri Oct 03 2025)

Table 2: The Selection Criterion Is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2015 – 2025	< 2015

Source: (Scopus AI, Fri Oct 03 2025)

Data Analysis

VOSviewer, developed by Nees Jan van Eck and Ludo Waltman at Leiden University, Netherlands (van Eck & Waltman, 2010, 2017), is a powerful and user-friendly bibliometric software widely adopted for the visualization and analysis of scientific literature. Renowned for its capability to generate intuitive network visualizations, cluster related items as well as produce density maps, VOSviewer enables researchers to explore co-authorship, co-citation, and keyword co-occurrence networks. This gives a detailed overview of research landscapes.

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Its interactive interface, coupled with continuous updates, allows for efficient exploration of large datasets. Features such as metric computation, customizable visualizations, and compatibility with diverse bibliometric data sources establish it as an indispensable tool for scholars who aim to derive meaningful perspectives from complex research domains.

A primary strength of VOSviewer emerges in its capability to transform intricate bibliometric datasets into visually interpretable maps as well as charts. By emphasizing network visualization, the software excels at clustering related items, analyzing keyword co-occurrence patterns, and generating density maps. Moreover, its user-friendly design accommodates both novice and experienced users, enabling efficient navigation and analysis of research structures. Continuous development ensures that VOSviewer remains at the forefront of bibliometric analysis, offering robust insights through metric calculations and highly customizable visual outputs. Its adaptability to various bibliometric data types, comprising co-authorship and citation networks, underscores its versatility and vital role in scholarly research.

For the current study, datasets comprising publication year, title, author names, journal, citations as well as keywords in PlainText format were retrieved from the Scopus database, covering the period from 2015 to October 2025. The datasets were then examined using VOSviewer version 1.6.20. Through the application of VOS clustering and mapping techniques, the software enabled the creation of network maps, serving as an alternative to the Multidimensional Scaling (MDS) method. Unlike MDS, which mainly computes similarity metrics like cosine or Jaccard indices, VOSviewer positions items in low-dimensional spaces so that the distance between any two items reflects their true relatedness (Appio et al., 2014). Furthermore, VOSviewer applies an optimized normalization method for co-occurrence frequencies using the association strength (AS_{ij}), defined as:

$$AS_{ij} = \frac{C_{ij}}{w_i w_j}$$

This metric represents “the ratio between the observed number of co-occurrences of items i and j and the expected number of co-occurrences under the assumption that co-occurrences of i and j are statistically independent” (Van Eck & Waltman, 2007). This provides a rigorous and statistically sound basis for mapping bibliometric relationships.

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Findings and Discussion

RQ 1: What Are the Research Trends in These Studies Based On the Year of Publication?

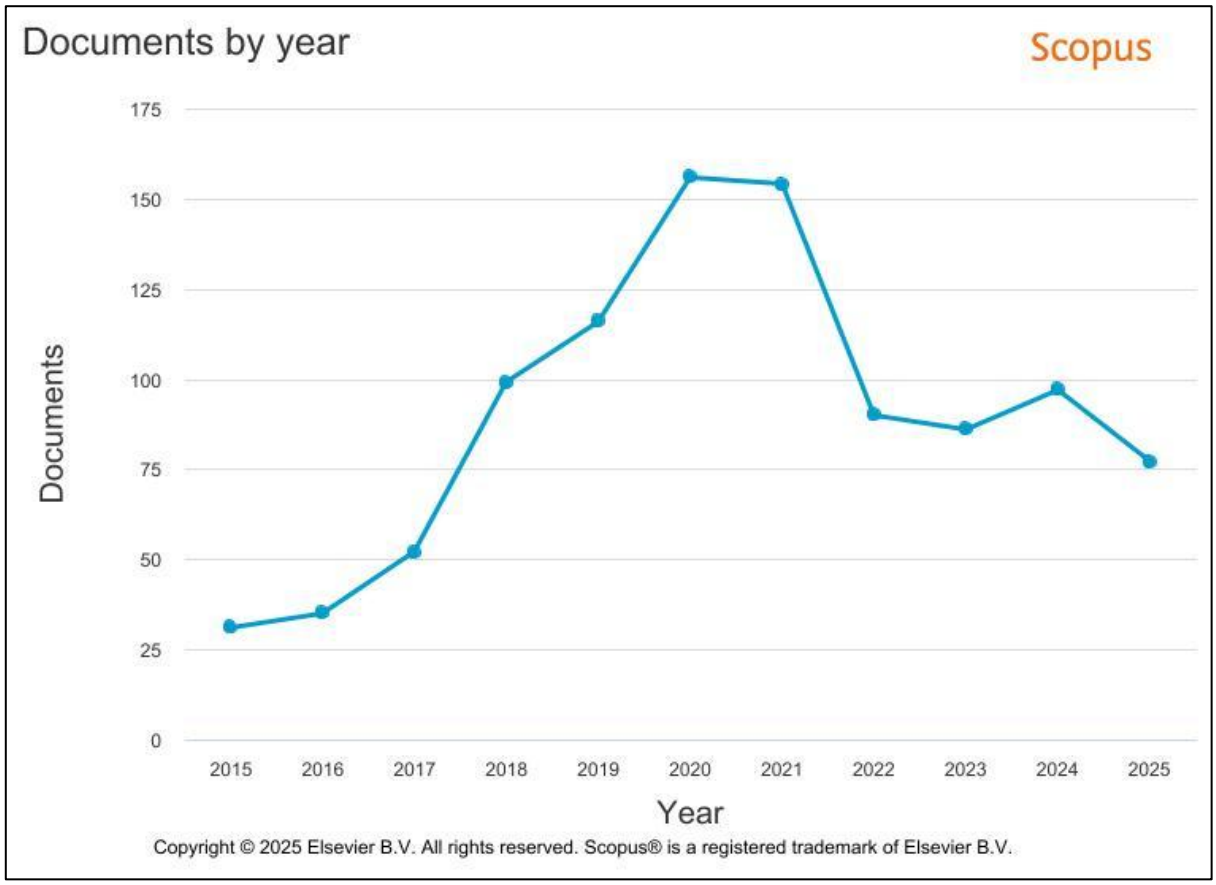

Figure 2: Number of Documents Based on Year of Publication

Source: (Scopus, Fri Oct 03 2025)

The publication trend from 2015 to 2025 demonstrates a clear trajectory of growth, peak, and gradual decline. Between 2015 and 2017, research output increased modestly from 31 to 52, suggesting the early stage of emerging scholarly attention in the field. A significant acceleration began in 2018 (99 publications), with a sharp jump in 2019 (116) and reaching its peak during 2020 (156) and 2021 (154). This surge may be associated with the global COVID-19 pandemic, which accelerated digital transformation, online learning, and academic interest in educational technologies and learning sciences. The increased reliance on digital platforms likely created an urgent demand for research, particularly in relation to motivation, student engagement, and mathematics learning, thereby stimulating scholarly publications during that period.

However, after 2021, the data reflect a decline: 90 (2022), 86 (2023), 97 (2024), and 77 (2025). This downtrend may be due to a post-pandemic normalization where the urgency for rapid publication reduced, and researchers shifted focus to other educational or interdisciplinary priorities. Funding allocation and research saturation could also explain the gradual decrease, as major questions raised during the pandemic years were already addressed, leading to fewer novel contributions. Nevertheless, the sustained higher output compared to pre-2018 levels

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indicates that the field has established stronger scholarly recognition and remains relevant, even though the research intensity is no longer at its pandemic-driven peak.

RQ 2: What Are the Most Cited Articles?

Table 3: Most Cited Articles

Authors	Year	Source title	Cited by
Theobald et al. (2020)	2020	Proceedings of the National Academy of Sciences of the United States of America	926
Lai & Hwang (2016)	2016	Computers and Education	593
Sun et al., (2018)	2018	Internet and Higher Education	225
Tokac et al. (2019)	2019	Journal of Computer Assisted Learning	221
Cho & Heron (2015)	2015	Distance Education	220
Lo & Hew, (2020)	2020	Interactive Learning Environments	179
Rimm-Kaufman et al. (2015)	2015	Journal of Educational Psychology	178
Hwang et al., (2021)	2021	Computers and Education	141
Faber et al. (2017)	2017	Computers and Education	140
Cai et al., (2019)	2019	British Journal of Educational Technology	113

Source: (Scopus, Fri Oct 03 2025)

Table 3 shows the top-cited articles in mathematics education. This table reveals a clear focus on active, technology-enhanced, and self-regulated learning approaches. The most cited work, Theobald et al. (2020) with 926 citations, emphasizes active learning to reduce achievement gaps for marginalized students in STEM, highlighting a strong research interest in equity and effectiveness of interactive pedagogies. Similarly, Lai & Hwang (2016) and Sun et al. (2018) focus on flipped classroom models and self-regulated learning, demonstrating that scholars

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prioritize strategies that promote autonomy and engagement in mathematics learning. The presence of meta-analytical studies (Tokac et al., 2019) and digital tools (Faber et al., 2017; Cai et al., 2019) further indicates that empirical evidence on technology-enhanced learning is highly valued. The range of journals, from Proceedings of the National Academy of Sciences to Computers and Education, also suggests that influential research spans both high-impact multidisciplinary journals and specialized educational technology outlets.

The citation patterns can be justified by both pedagogical relevance and methodological rigor. Articles that address pressing educational challenges, such as achievement gaps and student engagement, naturally attract broader attention, especially when paired with innovative methods like flipped classrooms, gamification, or AR-based tools. Furthermore, studies offering meta-analyses or experimental designs (Tokac et al., 2019; Faber et al., 2017) are likely to be cited more because they provide strong empirical evidence and generalizable findings. The moderate to high citations of works from 2015 to 2021 suggest that research in mathematics education has rapidly embraced technology and self-regulation strategies, aligning with global trends in digital learning and inclusive education. Overall, the data indicate that practical impact, technological integration, and evidence-based pedagogical approaches are key drivers of citation influence in contemporary mathematics education research.

RQ 3: Where Are the Top 10 Countries Based on the Number of Publications?

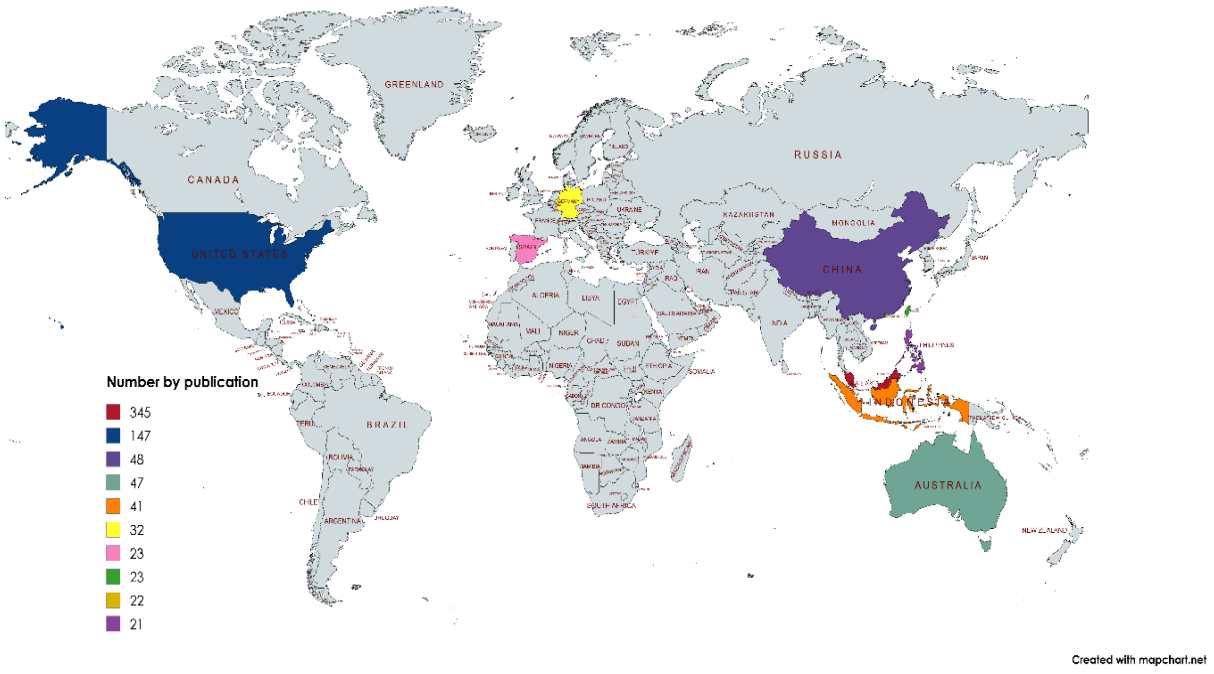

Figure 3: Country Mapping According on the Number of Publications
Source: (Scopus, Fri Oct 03 2025)

The distribution of publications by country shows a striking dominance of Indonesia, with 345 publications, more than double that of the United States (147), which is in second place. This significant output from Indonesia suggests a strong national emphasis on mathematics

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education and related research, likely driven by large-scale educational reforms, government funding initiatives, and the high number of local journals indexed in Scopus. The presence of local open-access journals and collaborative networks among Indonesian scholars could also explain why their publication volume surpasses that of more established research nations. Meanwhile, the United States maintains its traditional strength in research output, supported by well-funded institutions and international collaborations, but the gap behind Indonesia highlights the rising role of developing countries in global scholarly contributions.

Other countries such as China (48), Australia (47), and Malaysia (41) contribute moderately, reflecting regional research growth in Asia-Pacific. Germany, Spain, Taiwan, Hong Kong, and the Philippines each record between 21–32 publications, suggesting that while these nations have active academic communities, their research may be more specialized, selective, or limited by language and indexing practices. The relatively lower numbers for European countries compared to Southeast Asia could also reflect differences in research focus, where STEM education topics may not be as prioritized as in emerging economies. Overall, the data underscores Indonesia's exceptional role in driving research productivity in this field, illustrating how national policies, local journal visibility, and research networks strongly influence global bibliometric trends.

RQ 4: What Are the Popular Keywords Related to the Study?

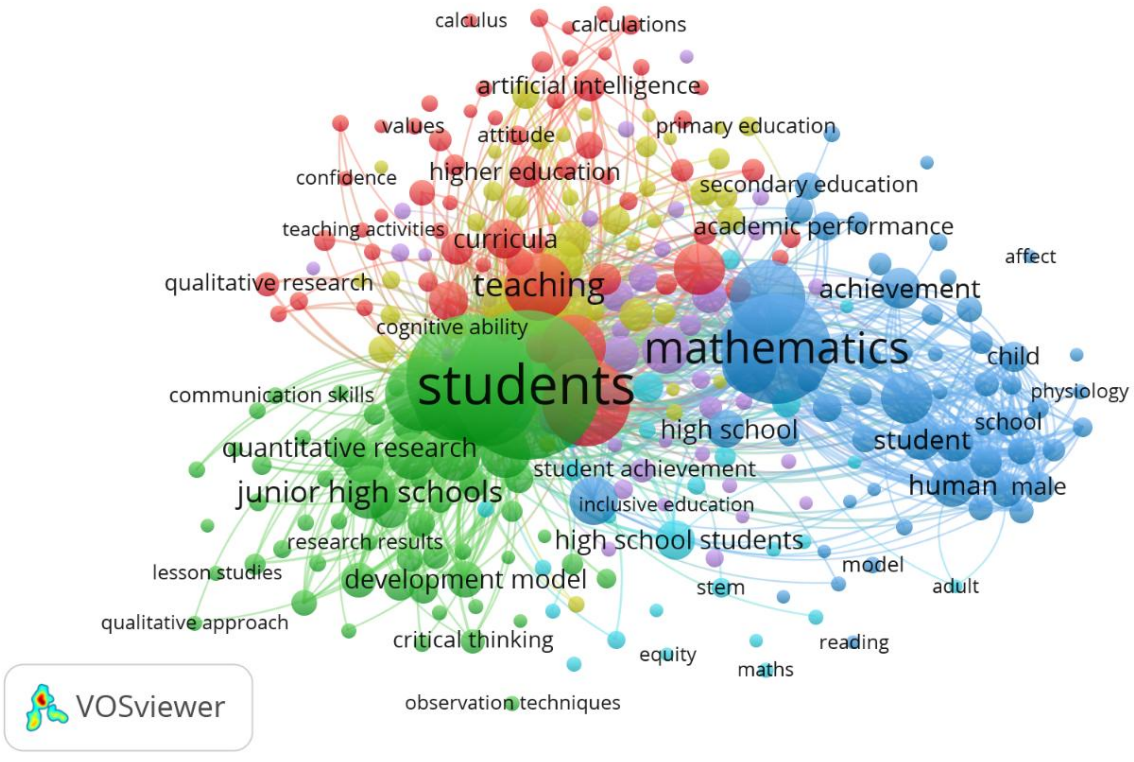

Figure 4: Network Visualization Map of Keywords' Co-Occurrence
Source: (Scopus, Fri Oct 03 2025)

Co-occurrence analysis of author keywords in VOSviewer helps identify how frequently keywords appear together across different publications, allowing researchers to uncover thematic structures, research hotspots, and intellectual linkages in a field. In this case, the map

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was generated using a full counting method with a minimum threshold of five occurrences. From a total of 2,187 keywords, 293 met the threshold, and a minimum cluster size of five produced six distinct clusters. These clusters represent thematic groupings such as mathematics learning, technology integration in education, student motivation, assessment methods, and STEM education. Each is linked by strong co-occurrence ties that highlight the interconnection of topics within the broader research landscape.

The results contribute significantly to the body of knowledge by highlighting the centrality of "students" and "mathematics learning" as dominant nodes, reflecting the field's emphasis on learner-centered approaches and technology-supported pedagogy. Strong link strengths with concepts like "motivation," "problem solving," "e-learning," and "educational technology" indicate the growing integration of digital tools and psychological factors in mathematics and education research. The clustering also underscores the interdisciplinary nature of the field, bridging education, psychology, computer science, and engineering. This mapping not only informs future research directions but also provides a conceptual overview of how educational research is evolving towards technology-enhanced, student-centered, and outcome-based learning models.

RQ 5: What Are the Patterns of Co-Authorship Relying on Countries' Collaboration?

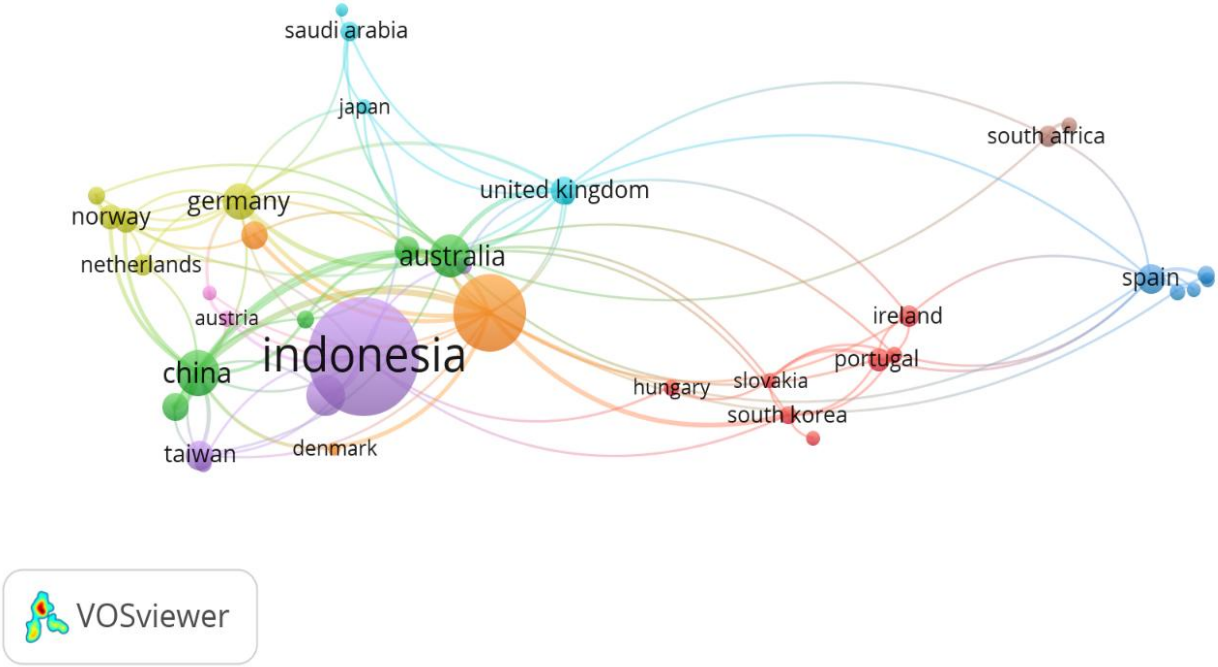

Figure 5: Network Visualization Map of Co-Authorship by Countries
Source: (VOSviewer, Fri Oct 03 2025)

Co-authorship analysis by countries in VOSviewer is a bibliometric method used to visualize international research collaboration by mapping how often authors from different countries co-publish together. This analysis highlights the strength of connections between countries, with larger nodes resembling higher publication output and thicker links indicating stronger collaborative ties. In this map, the settings applied were the full counting method with a

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minimum threshold of five documents per country. Out of 98 countries, 45 met the threshold, and with a minimum cluster size of five, the analysis produced nine clusters. These clusters represent groups of countries with stronger internal collaboration patterns, showing the global distribution of research partnerships.

The findings highlight the dominance of the United States, China, and Indonesia in terms of publication volume. The United States also leads in citation impact, suggesting both productivity and influence in the field. Countries like Australia, Germany, and the United Kingdom also show strong collaborative positions, while smaller nations such as Norway, Finland, and Portugal contribute through niche but impactful collaborations. The presence of multiple clusters reflects regional and international collaboration trends, where Asian, European, and Western countries form distinct but interconnected groups. This contributes to the body of knowledge by demonstrating how international cooperation enhances research visibility, knowledge transfer, and citation impact, reinforcing the importance of cross-border partnerships in advancing the global academic discourse.

Conclusion

This study's purpose was to offer a bibliometric perspective on student motivation and interest in mathematics, focusing on research trends, citation patterns, keyword dynamics, and international collaborations. The analysis of 993 documents retrieved from Scopus revealed several key findings that shape the intellectual structure of this research area. Publication trends showed rapid growth during the COVID-19 pandemic years, reflecting heightened global attention to digital and motivational aspects of mathematics learning, followed by a gradual decline as research priorities shifted. The most cited works highlighted the prominence of active learning, flipped classrooms, self-regulated learning, and technology-enhanced approaches, demonstrating that the integration of pedagogy with digital innovation has become central in mathematics education research. Keyword co-occurrence analysis identified six dominant clusters, pointing to recurring themes such as mathematics learning systems, problem solving, mathematics anxiety, e-learning, and psychological constructs like self-efficacy. Collaboration mapping emphasized the role of the United States, China, and Indonesia as major contributors, alongside growing participation from countries across the Asia-Pacific and Europe, illustrating the increasingly globalized nature of the discourse.

This study contributes to the field by offering a comprehensive synthesis of research developments in student motivation and mathematics learning, underlining the importance of technology integration, collaborative strategies, and learner-centered approaches. The findings have practical implications for policymakers and educators, particularly in designing interventions that sustain motivation and engagement across diverse educational contexts. However, the study is limited to Scopus-indexed publications and English-language outputs, which may exclude valuable perspectives from non-indexed or regional research. Future studies could expand the scope by integrating multiple databases, longitudinal citation tracking, and deeper qualitative reviews of influential works to enrich the understanding of evolving trends. Overall, this research underscores the significance of bibliometric analysis as a powerful tool to map intellectual progress, highlight global collaboration, and guide future inquiry into motivation and interest in mathematics, ensuring sustained innovation in both theory and practice.

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