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Mathematics Anxiety: A Systematic Literature Review with Bibliometric Analysis

Novita Maulidya Jalal
Faculty of Psychology, Universitas Negeri Makassar, Makassar City, South Sulawesi
Corresponding Author: Novita Maulidya Jalal, e-mail: (novitamaulidyajalal@unm.ac.id)

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ABSTRACT

This study aims to analyze mathematics anxiety as a significant psychological phenomenon among students at various educational levels and cultures. Using a Systematic Literature Review (SLR) approach and bibliometric analysis, this study identifies research trends, causal factors, impacts, and intervention strategies related to mathematics anxiety. The results indicate that mathematics anxiety negatively impacts the quality of students' learning and career choices. There has been a significant increase in publications since 2010, especially from countries such as the United Kingdom and the United States, indicating that this issue is receiving increasing attention. Various factors, including the role of teachers and cultural context, contribute to the development of mathematics anxiety, while interventions such as collaborative learning and the use of digital technology are effective in reducing this anxiety. The conclusions of this study emphasize the importance of designing educational programs that are sensitive to students' psychological aspects, with the hope of improving the quality of mathematics education and supporting students in their learning process.

Keywords: *mathematics anxiety, systematic literature review, bibliometric analysis*

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INTRODUCTION

Mathematics anxiety is a psychological phenomenon widely experienced by learners across educational levels and cultural contexts. It is characterized by feelings of tension, fear, and apprehension when confronted with mathematical tasks, which in turn disrupt cognitive processes such as working memory and problem-solving ability (Lau et al., 2022; Verdeflor et al., 2025). Mathematics anxiety not only affects academic performance but also has long-term implications for career choices, particularly in STEM fields that require strong numerical competence (Supekar et al., 2015). Students with high levels of mathematics anxiety tend to avoid mathematics-related activities, obtain lower grades in mathematics, and exhibit behaviors such as avoiding help-seeking when they make errors (Wang et al., 2025).

The contributing factors to mathematics anxiety are multifaceted, encompassing both school-related influences and students' personal experiences. Teachers play a significant role in either reinforcing or reducing mathematics anxiety. Supportive classroom environments, positive instructional practices, and teacher behaviors that promote psychological safety have been shown to lower mathematics anxiety, whereas punitive or pressure-inducing behaviors exacerbate it (Ismail et al., 2022; Verdeflor et al., 2025; Liu et al., 2024). Cultural context also shapes the strength of the relationship between mathematics anxiety and performance. Cross-national studies suggest that educational practices and cultural values influence students' perceptions of mathematics (Lau et al., 2022). In addition, self-perceptions, prior learning experiences, and academic preparedness contribute to the development of mathematics anxiety (Nolasco, 2025).

The measurement of mathematics anxiety has evolved alongside the needs of research and educational practice. Several instruments have been developed, such as the Weighted Scoring Based Mathematics Anxiety Rating Scale (WSB-MARS) and the Modified Abbreviated Math Anxiety Scale (m-AMAS), which not only assess anxiety levels but also categorize the severity of the condition (Tamal et al., 2021; Kul et al., 2024). The use of valid and reliable instruments is essential to accurately understand the degree of mathematics anxiety and to determine appropriate interventions. Various intervention strategies, such as cognitive reappraisal and emotion regulation, have demonstrated effectiveness in reducing anxiety while simultaneously enhancing mathematics performance (Pizzie et al., 2020; Pizzie & Kraemer, 2023). Beyond cognitive and emotional approaches, classroom-based strategies such as collaborative learning, material simplification, and the use of concrete examples have also been shown to alleviate mathematics anxiety (Verdeflor et al., 2025).

Technological advancements provide new opportunities through the implementation of digital game-based learning and digital mathematics training programs, which have proven especially effective for students with high anxiety levels (Ng et al., 2022; Ersozlu, 2024). These digital interventions have been found to increase motivation, enhance engagement, and reduce negative emotional reactions toward mathematics. Early intervention is particularly crucial, as mathematics anxiety emerging in childhood can have long-lasting effects on cognitive development, academic trajectories, and future career decisions (Supekar et al., 2015). Thus, a comprehensive understanding of the causes, consequences, and intervention strategies for mathematics anxiety is essential for improving the quality of mathematics learning.

Given the complexity of this phenomenon, the present study employs a Systematic Literature Review (SLR) combined with bibliometric analysis to provide a comprehensive overview of the research landscape on mathematics anxiety. Through this systematic approach, the study aims to identify research trends, measurement instruments, determining factors, and the most effective intervention strategies based on the latest empirical evidence. The findings are expected to serve as a valuable reference for educators, researchers, and policymakers in designing educational programs that are sensitive to learners' psychological needs, particularly in reducing mathematics anxiety and enhancing learning outcomes.

METHOD

This study employs a Systematic Literature Review (SLR) approach combined with bibliometric analysis to obtain a comprehensive overview of the development of research on mathematics anxiety. The SLR approach is used to systematically identify, evaluate, and synthesize empirical findings from various scientific publications using PRISMA guidelines. Bibliometric analysis is utilized to map the research landscape, identify trends, determine the most influential authors, examine collaboration patterns, and explore major thematic topics in the field of mathematics anxiety using software such as VOSviewer and Biblioshiny with the keyword "mathematics anxiety."

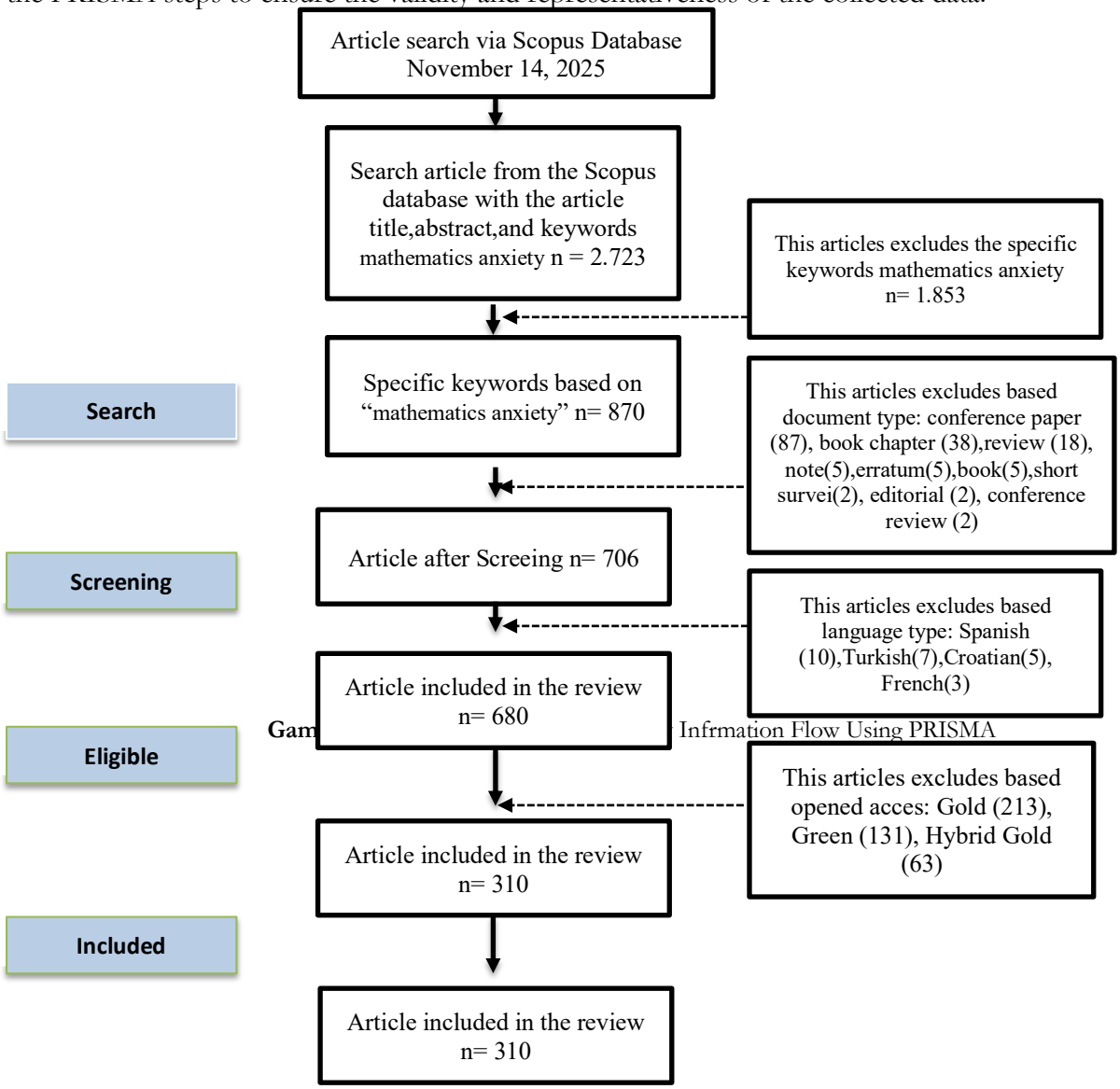
The inclusion criteria of this study consist of Scopus-indexed scientific articles published between 1983 and 2027, written in English, focusing on mathematics anxiety among students, and examining its causes, impacts, measurement instruments, or interventions. The exclusion criteria comprise non-scientific articles, non–peer-reviewed conference proceedings, editorials or book reviews, studies that do not explicitly address mathematics anxiety, articles without empirical data, studies irrelevant to the research objectives, and duplicate publications across databases.

The article selection procedure follows the four PRISMA stages: (1) Identification, in which articles were collected from three databases, resulting in an initial total of 2,723 publications; (2) Screening, where duplicates were removed and titles and abstracts were screened; (3) Eligibility, in which full-text assessments were conducted to determine alignment with the criteria; and (4) Included, where the final set of eligible articles was selected as the sample for the SLR and bibliometric analysis. Data interpretation was carried out using thematic analysis.

Bibliometric data were retrieved from Scopus in .csv format and analyzed through VOSviewer, covering co-authorship, co-citation analysis, keyword co-occurrence, and network visualization. Biblioshiny was employed to examine annual publication trends, author productivity,

the most productive countries, and the journals that published the largest number of relevant studies. The bibliometric results were used to construct a comprehensive research map of mathematics anxiety.

The research on mathematics anxiety began with a search of articles in the Scopus database, which yielded an initial total of 2,723 publications with the keyword "mathematics anxiety." After a screening process, 680 articles were found to meet the inclusion criteria. At this stage, relevant articles were analyzed to further define mathematics anxiety. The screened data included English-language articles and open-access documents, in an effort to obtain a comprehensive picture of the distribution and findings related to mathematics anxiety in educational contexts. This systematic process followed the PRISMA steps to ensure the validity and representativeness of the collected data.



Gam Infrmation Flow Using PRISMA

FINDING AND DISCUSSION

Finding

The findings of this study draw upon 310 Scopus-indexed articles on mathematics anxiety. The data were obtained through the identification of the number of published articles, publication trends over time, and journal sources. This study also highlights the most influential elements related to mathematics anxiety, particularly within the context of elementary school education.

RQ1: Does the exploration of mathematics anxiety remain a significant subject for future scientific research?

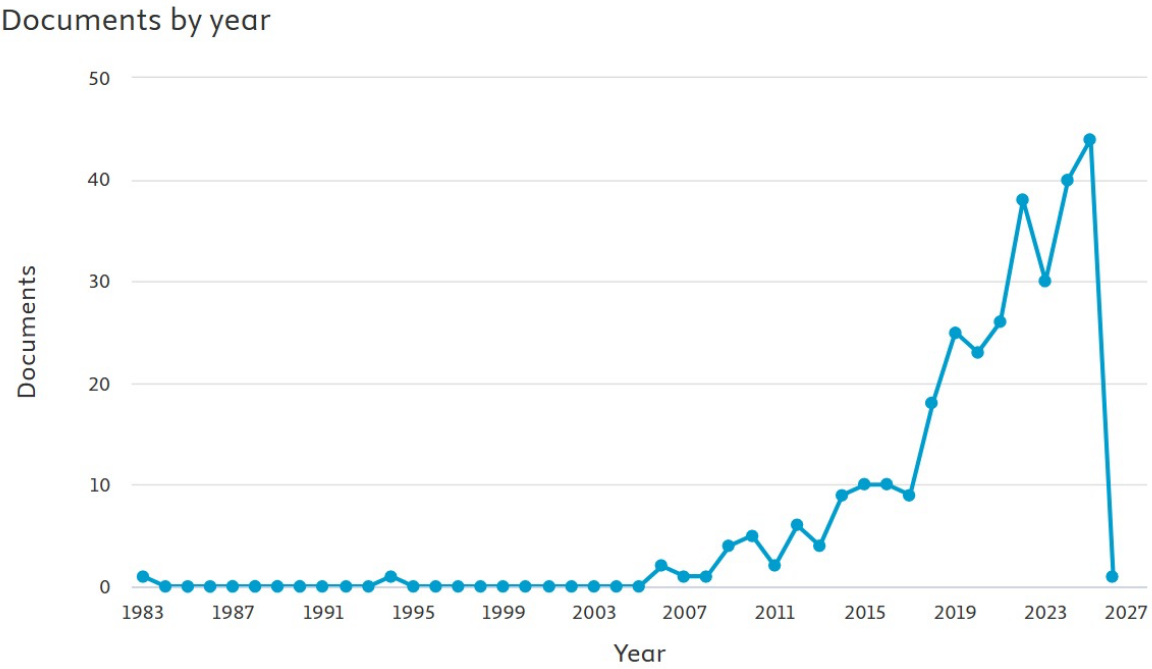
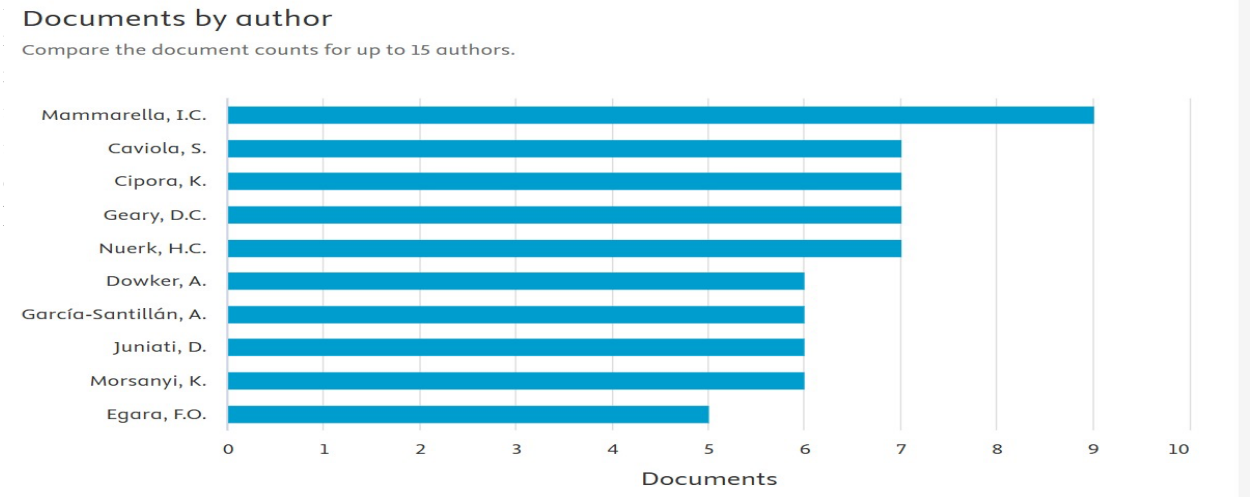


Figure 2. Number of Documents by Year

The publication trend indicates a substantial increase in research on mathematics anxiety over the past two decades. From 1983 to the early 2000s, the number of publications remained very low and relatively stagnant, suggesting that the topic had not yet gained considerable scholarly attention.



Bibliometric mapping of mathematics anxiety research shows that the most dominant contributions come from Mammarella, I.C., who leads with nine publications. Following closely are Caviola, S., Cipora, K., Geary, D.C., and Nuerk, H.C., each with seven publications, reflecting consistent and intensive scholarly engagement in examining cognitive and emotional factors in mathematics learning. Dowker, A., García-Santillán, A., Juniati, D., and Morsanyi, K. follow with six publications, enriching the theoretical and methodological diversity of the field. Egara, F.O. contributes five documents, showing active involvement, although to a lesser degree than core contributors. Overall, the distribution of author contributions indicates that the field is shaped by key researchers, primarily from cognitive and educational psychology, forming a robust and continuously expanding body of literature

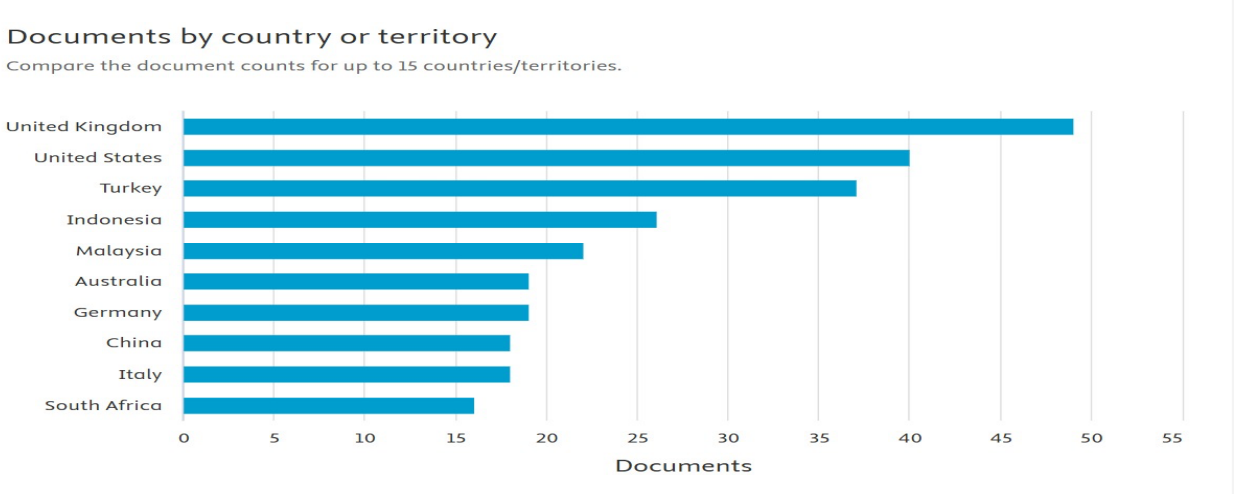


Figure 4. Documents by Country

The SLR and bibliometric analysis from Scopus data reveal considerable variation in publication contributions across countries. The United Kingdom ranks highest in the number of publications, followed by the United States and Turkey. Indonesia, Malaysia, and Australia also demonstrate significant activity in mathematics anxiety research. Furthermore, European countries such as Germany and Italy, alongside China and South Africa, contribute meaningfully to the global understanding of mathematics anxiety in education. These findings highlight that the challenges associated with mathematics anxiety are experienced globally, reinforcing the need for international collaboration in addressing this issue.

RQ2: How is the allocation of research investigations related to mathematics anxiety?

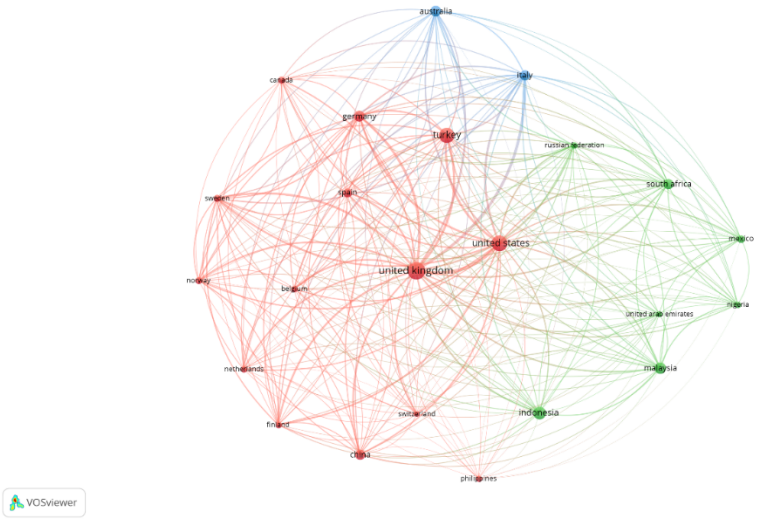


Figure 5. VOSviewer Network Visualization Output

The bibliometric visualization of co-authorship among countries indicates three dominant and strongly interconnected collaboration clusters. The first cluster (in red) is led by the United Kingdom, United States, Germany, Spain, Finland, Canada, and other Western European nations, forming the core of global research collaboration with highly intense linkages. The second cluster (blue) consists of Australia and Italy, which show strong internal connections and notable ties to European groups. The third cluster (green) comprises Asian and African countries, including Malaysia, Indonesia, Nigeria, the United Arab Emirates, Mexico, and South Africa, forming regional networks that remain significantly connected to major contributors such as the United States and China. This mapping illustrates that mathematics anxiety research is global in nature, with North America and Europe serving as research hubs, while collaborative networks are steadily expanding among developing countries in Asia and Africa.

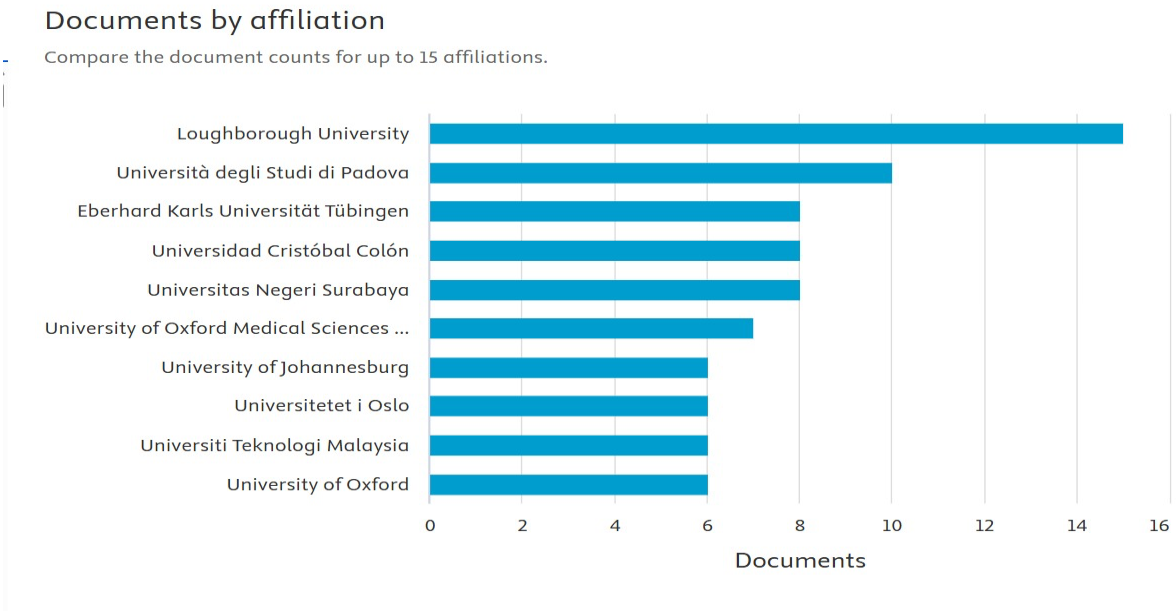
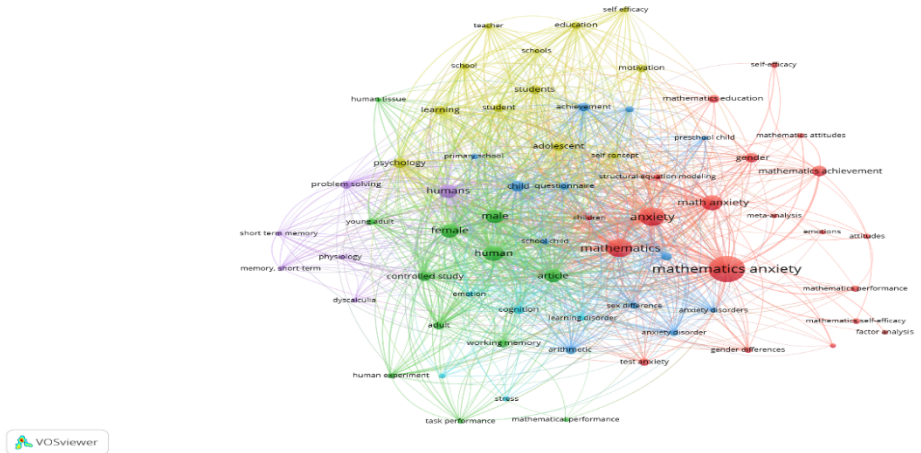


Figure 6. Documents by Affiliation

The Scopus data indicate that mathematics anxiety research is concentrated within several leading academic institutions. Loughborough University ranks first with the highest number of publications, followed by Università degli Studi di Padova and Eberhard Karls Universität Tübingen. These institutions have played crucial roles in advancing knowledge on mathematics anxiety and highlight the importance of academic collaboration. Other institutions, including the University of Oxford and Universiti Teknologi Malaysia, also actively contribute to research focused on the impact of mathematics anxiety on learning and student performance.



education, developmental psychology, cognitive psychology, and affective science.

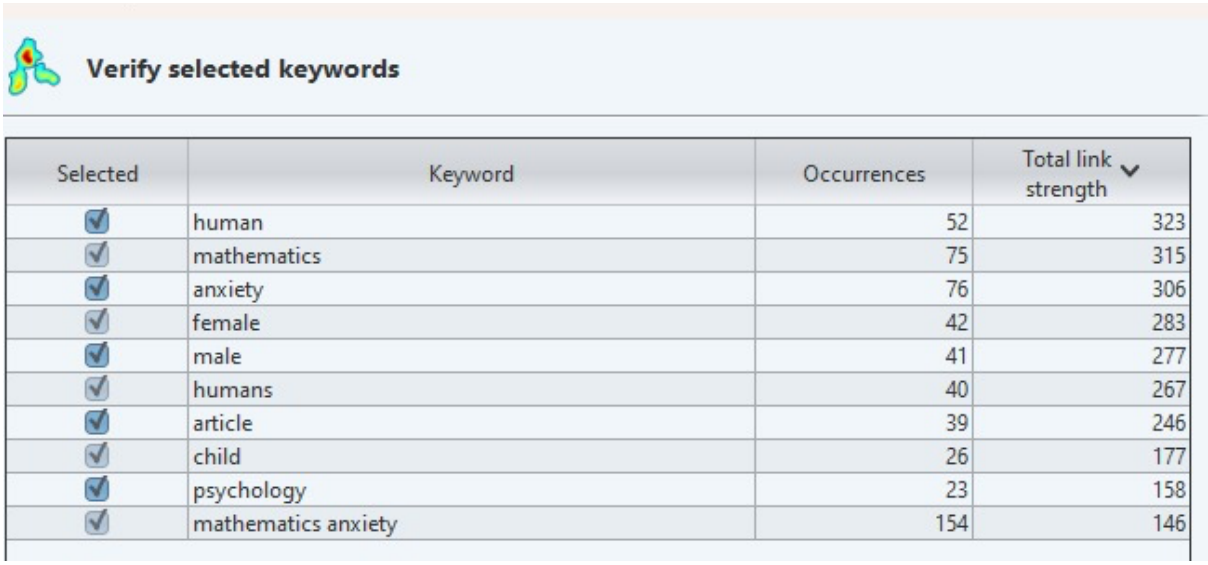


Figure 8. Co-occurrence Framework and Presentation of Key Terms

The keyword co-occurrence table shows that "mathematics anxiety" appears most frequently (154 occurrences), followed by general terms such as "anxiety," "mathematics," and "human," indicating a strong emphasis on psychological variables and educational contexts. High total link strengths for keywords such as "human" (323), "mathematics" (315), and "anxiety" (306) illustrate strong interconnectedness within the research network. The frequent appearance of "female" and "male" underscores the importance of gender as a widely examined dimension. Keywords such as "child" and "psychology" further indicate that mathematics anxiety research is rooted in developmental and educational psychology, covering a broad population range from children to adults. Collectively, these findings show that mathematics anxiety is conceptualized as a multidimensional phenomenon involving cognitive, affective, developmental, and social components.

DISCUSSION

Over the last two decades, research on mathematics anxiety has increased dramatically. Bibliometric analysis shows a sharp rise in publications after 2010, peaking at nearly 45 documents in 2023, indicating growing scholarly interest, especially given the topic's relevance to academic performance (Lau et al., 2022; Verdeflor et al., 2025). Mathematics anxiety not only affects learning outcomes but can also influence career choices, particularly in STEM fields requiring numerical proficiency. Students with high anxiety tend to avoid mathematics-related activities, leading to lower academic achievement and restricted career opportunities (Supekar et al., 2015; Wang et al., 2025).

Research has identified multiple contributing factors, including school environment and personal experiences. Teachers play a crucial role in fostering supportive learning environments; a positive classroom climate can reduce students' anxiety (Ismail et al., 2022; Liu et al., 2024). Findings also show substantial variation in research contributions across countries, with the United Kingdom, United States, and Turkey as leading contributors, reflecting the global relevance of mathematics anxiety (Ng et al., 2022; Uğraş, 2025).

Positive classroom environments are essential for reducing mathematics anxiety. Effective teaching practices and positive teacher–student interactions create comfortable learning spaces, enabling students to engage more openly (Ismail et al., 2022; Verdeflor et al., 2025). Cross-cultural differences further influence how students perceive mathematics. In cultures with high academic pressure, mathematics anxiety may be more prevalent (Lau et al., 2022).

Various measurement instruments have been developed to assess mathematics anxiety, such as the Weighted Scoring Based Mathematics Anxiety Rating Scale (WSB-MARS) and the Modified Abbreviated Math Anxiety Scale (m-AMAS), which help diagnose anxiety levels and guide appropriate interventions (Tamal et al., 2021; Kul et al., 2024). Emotion-based interventions such as cognitive

reappraisal and emotion regulation have been shown to effectively reduce anxiety and improve mathematical performance (Pizzie et al., 2020; Pizzie & Kraemer, 2023).

Collaborative learning strategies also help reduce anxiety by fostering emotional support among students (Verdeflor et al., 2025). Technological advancements offer new solutions, such as digital game-based learning, which boosts engagement and shifts attention away from anxiety (Ng et al., 2022). Early interventions are crucial, as mathematics anxiety emerging at a young age may have long-term consequences (Supekar et al., 2015; Wang et al., 2025).

Bibliometric analysis highlights key researchers such as Mammarella, I.C. and Caviola, S., whose work emphasizes cognitive and emotional factors in mathematics learning (Liu et al., 2024). Leading journals also play an essential role by integrating research from various disciplines, contributing to a more comprehensive understanding of mathematics anxiety (Wahyuni et al., 2025).

Mapping results show well-connected international collaboration clusters. This confirms that mathematics anxiety is a global research concern, with North America and Europe serving as central hubs, while Asian and African countries continue to expand their collaborative networks (Pizzie et al., 2020). Frequently emerging concepts such as "motivation," "self-efficacy," and "learning environment" indicate the need for continued exploration of how these factors interact with mathematics anxiety (Lau et al., 2022; Verdeflor et al., 2025).

These findings highlight the importance of education policies that consider students' psychological needs. Curricula must be designed not only to teach mathematics content but also to address anxiety associated with learning (Wang et al., 2025). Increasing awareness among educators, students, and parents is vital for developing more supportive learning environments (Ng et al., 2022; Tamal et al., 2021).

Mathematics anxiety research continues to grow as a multidisciplinary field. Contributions from education, developmental psychology, and neuropsychology enrich understanding of its complexity (Wahyuni et al., 2025). Future research should adopt integrative approaches, combining cognitive, emotional, and social perspectives. Longitudinal studies are also essential for understanding how mathematics anxiety develops and changes over time (Nolasco, 2025).

Overall, this study demonstrates that mathematics anxiety is a complex phenomenon requiring holistic, multidimensional approaches. Understanding its underlying factors enables the development of more effective interventions to help students overcome anxiety and enhance their learning outcomes in mathematics (Pizzie & Kraemer, 2023).

CONCLUSIONS

This study demonstrates that mathematics anxiety is a significant and complex phenomenon that can influence students' academic performance across various educational levels. Such anxiety not only negatively affects learning outcomes but may also shape students' future career choices, particularly in STEM fields that require strong numerical competence. As scholarly attention toward this issue continues to grow, contributions from multiple countries and leading researchers underscore the importance of exploring the cognitive, emotional, and cultural variables that contribute to the development of mathematics anxiety.

In this context, it is essential to develop intervention strategies aimed at reducing mathematics anxiety among students. The integration of technology in learning, collaborative learning approaches, and teacher training to foster positive classroom environments constitute strategic measures that need to be implemented. Through holistic and empirically grounded approaches, the quality of mathematics education is expected to improve, while students' anxiety can be minimized, enabling them to engage more actively in learning and better navigate the challenges associated with mathematics.

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