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Advances and perspectives in research on math anxiety: A systematic review and a bibliometric analysis

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ABSTRACT

Mathematics anxiety (MA) has attracted increasing attention in educational research. This study describes recent scientific production on MA, focusing on conceptualization, methodologies, limitations, and future research. A systematic review was conducted following the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) protocol, and twenty-eight studies published between 2019 and 2024 in Scopus, Web of Science, and ERIC were analyzed. A bibliometric analysis of recent scientific production on MA is also included. The systematic review examined definitions, methods, and limitations, while the bibliometric analysis explored trends, countries, authors, and funding in MA research. Results highlight MA's negative impact on academic performance, gender differences, and the need for effective interventions. The AMAS and m-AMAS were the most used instruments, despite psychometric issues. Longitudinal studies identified working memory and early numerical skills as predictors of MA. The United States leads publication output. The study underscores the need for sustainable interventions, cultural adaptation of instruments, and innovative approaches integrating neurocognitive and emotional factors.

Keywords: mathematics, review, education, achievement, literature

INTRODUCTION

Initially, Gough (1954) coined the term *mathephobia* to describe the anxiety about mathematics observed in students who, despite being competent in other domains, were unable to succeed in mathematics courses. This pioneering observation was followed by Dreger and Aiken (1957), who emphasized the need to investigate the emotional problems associated with mathematics learning and developed instruments to measure numerical anxiety. This effort was continued by Richardson and Suinn (1972), who introduced the *Mathematics Anxiety Rating Scale* (MARS), the first formal instrument to assess Mathematics Anxiety (MA), which later evolved into different versions adapted to diverse assessment needs.

The conceptual definitions of MA have varied and expanded over time. For instance, Lazarus (1974) described it as an apprehension toward mathematics, whereas Tobias (1978) emphasized the panic and mental paralysis that emerge when attempting to solve a mathematical problem. Later, Hembree (1990) referred to a generalized fear of engaging with mathematics, while Ashcraft and Faust (1994) highlighted a sense of tension or fear when confronted with mathematical content. These conceptions share the common notion that facing mathematical challenges may elicit an emotional response that hinders cognitive performance. Mathematics Anxiety (MA) is thus characterized as a negative emotional reaction toward mathematics that affects both academic achievement and individuals' emotional well-being.

According to Plake and Parker (1982), MA can be classified into *learning-related mathematics anxiety* and *evaluation-related mathematics anxiety*. Subsequent research, such as that of Taylor and Fraser (2013), has shown that these types of anxiety respond differently to a variety of environmental and individual factors. In this regard, Rubinsten and Tannock (2010) argue that educational settings, social relationships, and personal factors—such as gender, stereotypes, dyscalculia, or dyslexia—can contribute to the development of MA, thereby illustrating the complexity of this phenomenon. **Figure 1**, developed by Luttenberger et al. (2018), provides a framework for understanding MA and its effects.

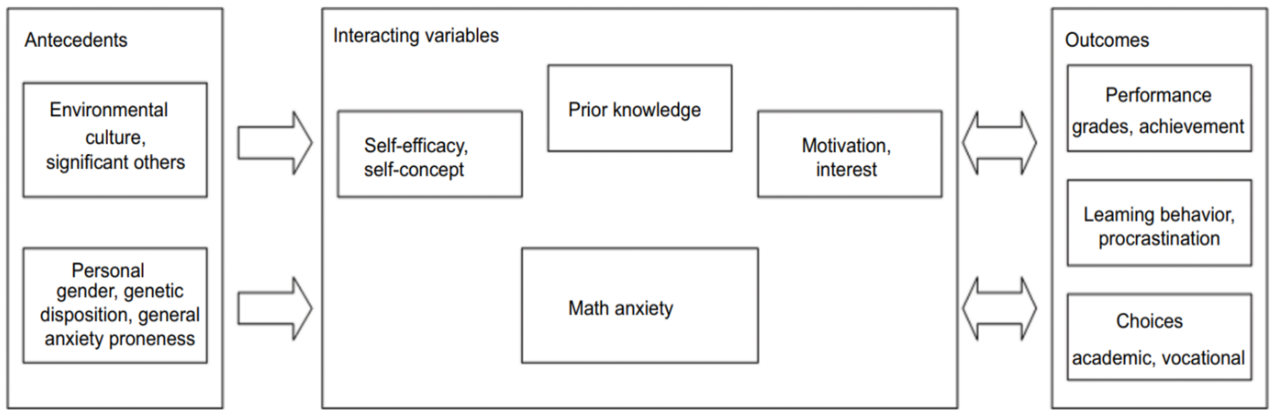

Figure 1. Variable affecting Mathematics Anxiety (MA) (Adapted from Luttenberger et al., 2018)

To guide the present review, we adopt the conceptual framework proposed by Luttenberger et al. (2018) which organizes the key variables involved in MA and their interrelations. This framework serves as a reference for categorizing the studies we analyzed and for interpreting their findings regarding and for interpreting their findings regarding antecedents, intervening mechanisms, and consequences of MA.

- **Factors (Environmental or Personal):** Environmental antecedents influencing the emergence of MA are related to contextual conditions, including culture, the characteristics of educational systems, and family and teachers' attitudes toward mathematics. Personal antecedents include trait anxiety and gender.
- **Variables Reciprocally Interacting with MA:** These include self-efficacy, self-concept, and motivation. Such variables interact with one another in the immediate learning process and influence each other in the long term. Together with MA, they shape outcome variables.
- **Outcome Variables (Educational):** Performance, learning behaviors, and academic choices are influenced by MA and, in turn, exert long-term effects on the subsequent development of MA.

The measurement of MA has evolved with the development of specific psychometric tools. The *Mathematics Anxiety Rating Scale* (MARS) by Richardson and Suinn (1972) marked the beginning of this line of research, followed by shorter adaptations such as the *Abbreviated Math Anxiety Scale* (AMAS) (Hopko et al., 2003) and its modified version for children, the m-AMAS (Szczygieł, 2019). However, recent studies such as those by Schmitz et al. (2019) have highlighted limitations in the internal consistency of these scales and the need for cultural adaptations to ensure validity across diverse contexts.

The relationship between MA and mathematical performance (MP) is one of the most consistent findings in the literature. For instance, Zhang et al. (2019) confirmed a significant negative correlation between the two variables. Longitudinal studies, such as those by O'Connor et al. (2023) and Lichtenfeld et al. (2023), have shown that early numerical skills and enriched family environments can mitigate the long-term effects of MA on MP. These findings underscore the importance of early interventions to prevent a self-perpetuating cycle of low self-efficacy and poor academic achievement.

MA does not affect all groups equally. For example, Girelli (2023) reported gender disparities, with women exhibiting higher levels of anxiety due to social stereotypes that associate mathematics with male competence. At the cultural level, Megreya et al. (2022) noted that adaptations of instruments such as the m-AMAS to different contexts require adjustments to capture students' unique experiences in diverse regions.

Several strategies have proven effective in reducing MA. For example, Wahyuni et al. (2024) demonstrated that fostering self-confidence enhances problem-solving in geometry and significantly reduces anxiety. Similarly, Ellianawati et al. (2021) showed that analogy-based learning can alleviate anxiety associated with specific mathematical tasks. While promising, such interventions must be tailored to the specific characteristics of students and educational settings.

The growing number of publications on MA reflects an increasing interest in understanding and addressing this phenomenon. Nonetheless, important challenges remain. Daches Cohen et al. (2021) pointed out that the reliance on self-reports may introduce bias, while Schmitz et al. (2019) cautioned against invariance problems when scales are applied across groups. These issues highlight the need for more robust methodological approaches, such as the use of mixed analyses and more diverse samples.

In summary, mathematics anxiety (MA) is a multidimensional phenomenon that impacts students' academic performance, self-esteem, and career choices, underscoring the urgent need for educational and psychological interventions that address both its emotional and cognitive roots. Despite the expanding body of research on MA, significant gaps remain. There are relatively few updated and openly accessible systematic reviews that comprehensively synthesize recent findings, which hinders teachers, researchers, and psychologists from fully understanding and mitigating the problem. Moreover, the lack of specialized dissemination channels for relevant findings highlights the need to improve scientific communication and knowledge transfer. Although methodological diversity reflects the richness of the field, it poses challenges for comparability and generalization, complicating the identification of trends and research priorities. This context makes it imperative to develop a systematic review that not only integrates available evidence but also identifies priority areas for future research, evaluates the impact of methodological diversity, and determines the most effective channels for disseminating the knowledge produced.

Accordingly, this study seeks to answer the following research questions:

RQ1. How has mathematics anxiety (MA) been conceptualized in recent publications?

RQ2. What methodological approaches predominate in MA research, and what are their main limitations?

RQ3. What trends, gaps, and projections emerge from the scientific literature on MA?

MATERIALS AND METHODS

The article combines a systematic review and a bibliometric analysis of the selected databases. The systematic review applies the PRISMA 2020 guidelines (Page et al., 2021) for reporting. This section describes the procedures of both analyses to provide transparency to the article.

Systematic Review Method

The PRISMA 2020 flow diagram (**Figure 2**) ensures transparency and replicability in the document retrieval and screening phases.

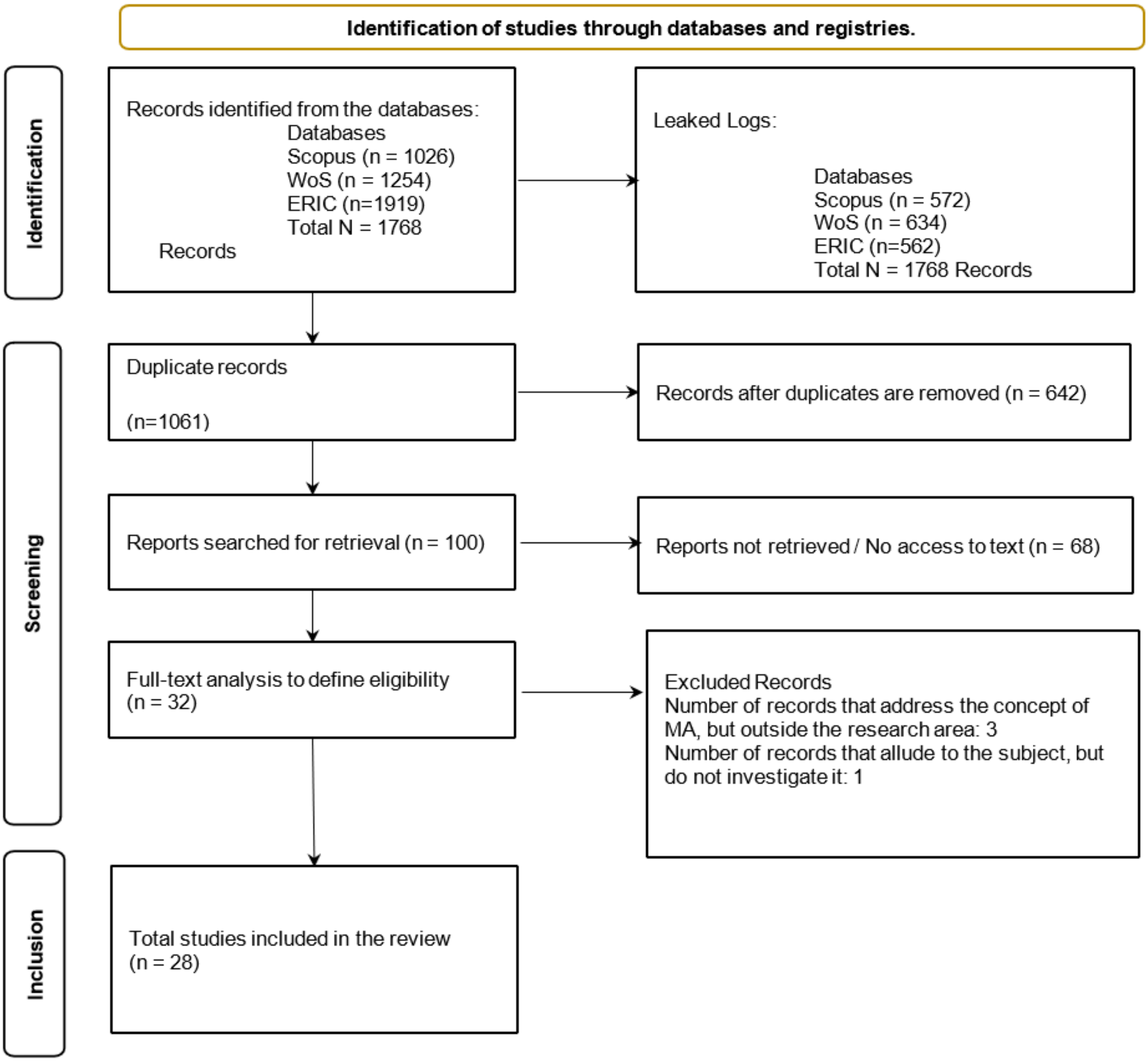

Figure 2. Prisma flow diagram, variable affecting Mathematics Anxiety (MA) (Adapted from Page et al., 2021)

In March 2024, a single reviewer conducted a systematic review across three different electronic databases (WOS, Scopus, ERIC) up to April 2024. WOS and Scopus were selected for indexing articles of international significance, while ERIC was chosen due to its specialization in education.

The identification criteria were as follows: Reason 1. Publications published within the last 5 years, i.e., after 2019. Reason 2. Publications that are Open Access or provide the full text in the corresponding database, as the researcher lacks funding to obtain paywalled publications. **Table 1** shows the search terms used across titles, abstracts, or keywords.

Table 1. Records of key terms according to the databases used in the systematic review (SR)

Key Words	Scopus	WOS	ERIC
"Math anxiety"	272	327	231
"Mathematics anxiety"	191	188	230
“Mathemafobia”	0	0	0
"Numerical anxiety"	13	2	18
"Math stress"	3	0	25
"Math anxiety" AND "review"	9	18	11
"Mathematics anxiety" AND "review"	0	12	12
"Math anxiety" AND "longitudinal"	17	33	6
"Math anxiety" AND "origin"	8	2	8
“Math anxiety” and “questionnaire”	59	52	21
“Math anxiety” and “mixed”	1	0	0
“Mathematics anxiety” AND “mixed-methods”	1	0	28

To verify the reliability of the initial search, it was repeated 15 days later using the same terms, confirming that the same results were obtained. Thus, in the first phase, 1,768 publications were identified, and their titles were exported.

Subsequently, screening was performed using the following exclusion criteria: Reason 3. Duplicate publications: 1,065 excluded. Reason 4. Publications not relevant to the educational or psychological field: 61 excluded. Therefore, 642 publications were identified for the next analysis phase.

Among the 642 publications to be analyzed, an inclusion criteria system was used to select articles aimed at answering the research questions.

To address RQ1: “How has mathematics anxiety been conceptualized in recent publications?”—given that reviews synthesize findings and the current state of the research topic—the following inclusion criteria were applied:

Reason 5 (n5). Reviews that include the evolution of the concept of MA, or bibliographic, systematic, and literature reviews.

To address RQ2: “What methodological approaches predominate in MA research, and what are their main limitations?”—from the analysis phase, publications with the following characteristics were selected:

Reason 6 (n6). Publications that study instruments for assessing MA.

Reason 7 (n7). Publications with a longitudinal study design.

Reason 8 (n8). Publications that include mixed methods, in order to compare findings across different methodological approaches.

After applying criteria n5 through n8, 100 of the 642 publications met the inclusion criteria. Of these, only 32 were retrievable in full text through Open Access sources and were therefore eligible for detailed analysis. While this decision ensured transparency and reproducibility of the review process, it may have excluded relevant studies available only through subscription-based access, representing a potential limitation of the review.

After being downloaded and analyzed by a single reviewer who employed a dual-review process combining selective reading of titles, abstracts, and/or conclusions of the documents, as well as digital tools, three articles were excluded because, despite containing the specified keywords in their abstracts, they did not actually meet the characteristics outlined in reasons n5, n6, n7, and n8 (Reason n10). Finally, another of the 32 documents was found not to investigate MA (Reason n11).

With the 28 final selected documents, a table was constructed for analysis. Each article was described considering the following categories: (1) year of publication, (2) research team, (3) title, (4) objective, (5) sample, (6) approach, (7) results and conclusions, (8) research limitations, and (9) proposals for future research. This allowed for a more detailed analysis of differences among publications and enabled organization into four tables based on publication types: reviews, publications dealing with MA measurement instruments, publications with longitudinal designs, and publications using mixed-method approaches. These tables are presented in the results section. The researcher judged that this organization facilitates the visualization of patterns, trends, and comparisons in a more structured manner. The PRISMA protocol was used to determine the quality of the systematic review.

Bibliometric Method

For the bibliometric analysis, a non-experimental, cross-sectional design was adopted. At a single time point, a single researcher collected data on the following characteristics of the topic:

- Number of publications containing the keyword "Math anxiety" in 5-year intervals, starting from its first recorded publication in the databases.
- Country of origin of the research.
- Most cited researchers and their affiliations.
- Types of publications and publication areas.
- Sponsors or funding sources.

Searches were conducted in Scopus, WOS, and ERIC. For the first characteristic – the count of publications using the keyword 'Math anxiety' in 5-year intervals – the analysis was performed from 1970 onward. For the remaining characteristics, publications were analysed by year from 2019 onward. The internal tools of Scopus and WOS were employed for these analyses, but ERIC does not allow this type of classification. These bibliometric indicators were analysed descriptively.

The use of both analyses provided a comprehensive perspective of the field, addressing key questions regarding priority research areas, the impact of methodological diversity, and the most effective channels for disseminating knowledge on MA. This methodological design ensures a deep and structured understanding of the phenomenon, establishing a solid foundation for future research.

RESULTS

The results are organized to address the three research questions. Section *Findings from the Systematic Review* presents findings related to the conceptualization of MA (RQ1) and to methodological approaches and their limitations (RQ2). Section *Findings from the Bibliometric Analysis* presents findings related to trends, gaps, and projections (RQ3).

Findings from the Systematic Review

The following section presents the qualitative findings from the 28 analyzed publications. The method for classifying the articles into four categories consisted of a thorough reading. These are divided into groups: systematic reviews and similar designs, publications including instruments, longitudinal studies, and mixed-methods research.

Evidence from reviews and similar designs

Past systematic reviews included in the study provide an overview of the state of research on MA, highlighting its conceptualization as a multidimensional construct. **Table 2** presents the most relevant information extracted from these 6 reviews.

Table 2. Summary of reviews

Authorship	Objective	Approach	Design
Ribeiro and Carmo (2024)	To identify, describe, and compare interventions aimed at reducing mathematics anxiety, and to emphasize the need for further empirical studies in this area to consolidate such interventions.	Qualitative	Systematic review
Balt et al. (2022)	To systematically review research on interventions designed to reduce mathematics anxiety (MA) in school-aged children and to evaluate the effectiveness of these interventions in improving students' attitudes toward mathematics and their mathematical performance.	Mixed	Systematic review
Finell et al. (2022)	To conduct a meta-analysis to investigate the mediating role of working memory in the relationship between mathematics anxiety (MA) and mathematical performance (MP).	Quantitative	Meta-analysis
Khasawneh et al. (2021)	To identify the barriers and causes of mathematics anxiety (MA) among university students.	Qualitative	Scoping review
Girelli (2023)	To address the relationship between gender and mathematical abilities, and to examine the factors that may influence these disparities.	Qualitative	Systematic review
Zhang et al. (2019)	To explore the connection between mathematics anxiety (MA) and mathematical performance (MP).	Quantitative	Meta-analysis

The analysed studies employ diverse methodological approaches to explore mathematics anxiety (MA) in different contexts, focusing on its impact on mathematical performance (MP), social barriers, gender biases, and relationships with teachers. Zhang et al. (2019) identified a consistent negative correlation between MA and MP, emphasizing the importance of targeted interventions. In the same line, Khasawneh et al. (2021) complemented this finding by mapping facilitators and barriers, highlighting the role of gender and self-efficacy. Girelli (2023), through a mixed-methods approach, identified significant differences between men and women in experiencing and overcoming MA. Ribeiro and Carmo (2024) identified effective strategies, such as psychological support and relaxation techniques, to reduce MA. Finell et al. (2022) underscored that working memory functions as a mediator between MA and MP, suggesting that its enhancement may mitigate the negative effects of MA.

From a global perspective, these studies emphasise the need for mixed methods approaches that integrate qualitative and quantitative perspectives, thereby providing a more multidimensional understanding of MA. Beyond specific mediator such as working memory, the systematic review by Balt et al. (2022) provides a critical synthesis of intervention research, identifying that most available studies are relatively recent and that interventions can be broadly categorized into math instruction and cognitive-behavioral interventions, mirroring approaches found in adult research. However, Balt et al. also highlight that the evidence base remains inconclusive; they found mixed effects for both approaches and noted that no direct statistical comparisons have been made to determine which is superior. Furthermore, they point out that a considerable number of studies reported MA reductions.

The findings also identify critical areas for future research, such as the long-term evaluation of interventions to determine their sustained impact, the development of specific strategies for different age groups, and the integration of educational technologies in curricula. Furthermore, exploring the relationship between working memory and MA through neurocognitive mechanisms and its influence across educational levels is recommended. Cross-cultural analyses and the evaluation of different types of mathematics assessments could also enrich the findings, promoting more effective and context-sensitive strategies to address MA.

Evidence from instrument-based studies

To address the question of how MA has been measured in the last five years, publications analysing existing questionnaires for assessing MA were reviewed. **Table 3** presents a summary of these publications.

Table 3. Summary of publications that analyze questionnaires to measure AM

Author	Objective	Instrument	Limitations of the instrument
Megreya et al. (2022)	To measure psychometric properties of an Arabic version of (m-AMAS) and gender differences in MA in Qatari students	Modified and Abbreviated MA Scale (m-AMAS) / 9 items	Self-reports. Generalization: exclusively students from grades 7 to 10. Ceiling and floor effects. Measure invariance: There was a small measure non-invariance between girls and boys on the math assessment anxiety (MEA) subscale in grade 9.
Schmitz et al. (2019)	Test the metric invariance and scalar of the (AMAS) scores between sexes and age groups. To corroborate the reliability and validity of these scores	Abbreviated Math Anxiety Scale (AMAS) / 9 ítems	Specific problem with one of the items. This item showed cross-loads in the group of female university students. Indicating a limitation in the ability of the AMAS to measure AM uniformly across all groups.
Orbach and Fritz (2022)	To investigate the interaction between attention control and affective factors, such as anxiety, in predicting PM in children aged 10 to 11 years.	State Mathematics Anxiety Questionnaire, state-MAQ / 14 ítems	Paper-and-Pencil Assessment: Not a direct method for measuring specific excitation related to autonomic nervous system mathematics. Limits accuracy in measuring AM. Impact of Attention Tasks with Digits: Tasks involving digits may influence the outcomes of children who struggle with MA or math in general, suggesting the need to compare sustained attention tasks with and without digits for a more accurate assessment.
Dyulicheva (2021)	Develop a methodology to detect MA by analyzing student opinions in MOOCs (Massive Open Online Courses)	Use of the VADER algorithm for sentiment analysis, the k-means clustering technique to group content with negative sentiment, and sentence representation based on the BERT language model.	Limited dataset size Challenges in pattern extraction: Extracting sentences with negative sentiment and sorting them into clusters may not capture all the nuances of students' experiences and emotions. These limitations indicate that, while the proposed method is useful, its effectiveness depends on the quantity and quality of the data available, and the accuracy of the text mining and sentiment analysis techniques used.
Daches Cohen et al. (2021)	To provide a comprehensive model of the nature of the links between AM, emotional regulation, and mathematical performance in adults.	Abbreviated Math Anxiety Scale (AMAS) / 9 ítems + State-Mathematics Anxiety Questionnaire (state-MAQ) / 14 ítems	Evaluation of self-reports may be subject to response biases
Szczygieł (2020)	Provide additional data on the nature of MA in students in grades one through three	Math Anxiety Questionnaire for Children (MAQC) / 12 ítems	Psychometric Properties: they need improvement and further development. Sample Size: The researchers suggest 800–1000 observations if the weighted least squares (DWLS) estimator is applied. Due to weak or moderate correlations between items. Model Fit-Fit Evaluation: The evaluation criteria for model fit should be more stringent if DWLS is used instead of the maximum likelihood (ML) estimator.
Szczygieł (2019)	To analyze the validity and reliability of the modified Modified Abbreviated MA Scale for Primary School Children (mAMAS-E), designed for early school-age children.	Modified Abbreviated MA Scale for Elementary Children (mAMAS-E) / 9 items	Low Internal Consistency ($\alpha = .59$), in the learning subscale the items are related. Low Factor Loads for the items of the learning subscale suggests that the items describe various mathematical situations that are not related. Some items may not be appropriate for young children's level of language development or may not apply to their experiences.
Lukowski et al. (2019)	Examine the dimensionality of math-specific anxiety. To investigate the relationship between these dimensions of MA and achievement in mathematics.	MARS-E (Mathematics Anxiety Rating Scale – Elementary) / 26 ítems	Item interpretation: Some items may be interpreted differently by students, affecting the consistency and accuracy of measurements. Differences in discrimination and threshold parameters between items indicate that not all items are equally relevant or difficult, suggesting that a simple summed score might not adequately capture MA. Context of the assessment: The assessment was conducted at the child's home in a low-pressure situation, which could have influenced the anxiety response. In more formal or high-pressure contexts, such as a classroom, results may vary.
Pizzie and Kraemer (2019)	Develop and validate the Academic Anxiety Inventory (AAI), a self-report measure designed to assess academic anxiety across different domains. to determine whether AM can be significantly distinguished from other types of academic anxiety and to assess the reliability and validity of this new measure.	The math subscale of the Academic Anxiety Inventory (AAI) / 10 items	Low sample diversity: middle- and upper-class individuals, mostly "*white.*" This does not adequately represent the racial and ethnic diversity of the U.S. population. Variability in anxiety patterns: Although AAI constructs were validated in samples of college students and adolescents, differences in anxiety patterns between these and younger populations may affect the results.

Recent publications highlight the predominant use of questionnaires such as the AMAS and m-AMAS to measure mathematics anxiety (MA), owing to their speed and practicality. However, they present significant limitations. Szczygieł (2019) identified issues of internal consistency in the learning subscale of the m-AMAS-E and recommended the use of large samples and strict criteria to confirm its factorial structure. Likewise, Schmitz et al. (2019) reported problems with cross-loadings in items administered to female university students, reflecting challenges in achieving measurement invariance across groups. Moreover, although self-reports are practical, they are prone to response biases as well as ceiling and floor effects, which compromise the ability to discriminate levels of MA and mathematical performance (MP). According to Megreya et al. (2022), such problems are common in data derived from school examinations, hindering accurate evaluations.

Future research should address these limitations by adapting questionnaires to cultural contexts, improving internal consistency and factor loadings, and ensuring measurement invariance across groups. Additionally, complementary methodologies—such as genetic analyses and physiological measurements—are recommended, as they may provide novel insights. Innovative tools such as VADER and BERT have enabled the identification of emotional patterns associated with MA, including regret over missed opportunities and a gradual decline of MA in online courses (Dyulicheva, 2021). This underscores the importance of combining traditional and advanced approaches to deepen the understanding of MA.

Evidence from longitudinal studies on MA

Longitudinal studies are essential for analysing the development of MA from early ages, validating instruments such as the m-AMAS-E in diverse contexts, and evaluating educational interventions that mitigate its impact and improve MP. This allows for the opening of new lines of inquiry. **Table 4** provides a summary of the publications employing a longitudinal design.

Table 4. Summary of publications employing a longitudinal design

Authorship	Objective	Instruments	Sample and duration of tracking
Song et al. (2021)	To examine the longitudinal relationships between MA and PM in students in second to third grade (Primary), and to explore the role of working memory in those relationships.	Math Anxiety Scale for Children. Math tests of number comparison, arithmetic fluency, and math problem solving, and working memory was assessed once in second grade.	244 children (45% boys) from schools in suburban areas of a large Canadian city. They spoke English at home (90%). They were enrolled in schools where the language of instruction was French (n = 152). Data collected on two occasions: once in grade 2 and again a year later in grade 3. (Duration 1 year).
Van der Ven et al. (2023)	Investigate how the interaction between WM and emotions in front of mathematics (anxiety and enjoyment) explains the MP of Primary students. To explore whether these relationships vary according to the type of mathematical test and the age of the students. Create an integrative model that explains how cognitive and affective factors together affect MP in the Primary stage.	Mathematical Emotions Questionnaire (MMCQ) and statistical method: Assesses anxiety and enjoyment of mathematics (specific subscales to measure thoughts and anxiety). Computerized Working Memory Tasks: visual-spatial and verbal memory. Cito Mathematics Tests. Arithmetic Tempo Test.	4471 primary school children from 32 schools in the Netherlands from grade 2 to grade 6. Mean age T1=9.42 at baseline, with a standard deviation of 1 year and 6 months (50.6% children). Collection on two occasions in the 2012-2013 academic year: First Measurement (Q1): September-October 2012. Second Measurement (Q2): January-February 2013. (Duration 1 term).
O'Connor et al. (2023)	To investigate whether basic and formal math skills at the age of 4 and 5 years predict AM at the age of 7-8 years. To examine the cross-sectional relationships between AM and MP in children aged 7-8 years, to understand the relationship between early basic numeracy skills and AM development.	Revised Child Math Anxiety Questionnaire (CMAQ-R) and the Early Elementary School Abbreviated Math Anxiety Scale (EES-AMAS) to measure AM, and various tasks: numerical comparison, numerical ordering, order working memory, non-symbolic addition, number line estimation, and counting.	60 boys (31 girls), who were evaluated during their first year (T1 = 4.92 years), second year (T2 = 6.17 years), and fourth year of primary school (T3 = 8.25). (Duration 3 years).
Gashaj et al. (2023)	Explore how early numeracy skills, the learning environment at home, and the absence of MA influence children's MP in school.	Numerical estimation, magnitude comparison, and conceptual subitization tasks to assess early numeracy skills, along with an MA questionnaire and a home learning environment questionnaire completed by parents. In addition, an adaptation of the Matrix subtest of the Working Memory Test Battery for Children and three subtests of the Matrix were used to measure mathematical achievement.	85 children recruited from different kindergartens in rural and urban areas near Bern, Switzerland. The mean age at the first measurement point (T1) was 6.42 years (SD = 0.31 years), with 46 boys and 42 girls. At the second measurement point (T2), the mean age was 7.98 years (SD = 0.31 years). (Duration 2 years).
Lichtenfeld et al. (2023)	Examine the development of joy, boredom, and MA from second through fourth grades and the relationships between these emotions and PM.	Annual assessments that measured emotions during learning, math tests, and their academic grades and MP test scores. Collected by modeling latent structural equations.	670 German students with a mean age of 8.45 years, of which 51.0% were female at the start of the study. T1 = 8.45 years, T2 = 9.53 years, T3 = 10.32 years. (Duration 3 years).

Table 4 (Continued). Summary of publications employing a longitudinal design

Authorship	Objective	Instruments	Sample and duration of tracking
Kim et al. (2023)	To examine the role of peers in the development of AM during early adolescence. To investigate whether adolescents develop similar levels of AM to their friends (influence effect) and whether adolescents with similar levels of AM tend to form friendships with each other (selection effect).	Questionnaires to assess MA and academic reputation among peers, and a social network analysis with the Markov chain algorithm to analyze friendship dynamics and MA.	237 students from third to sixth grade (114 girls) from two schools. Distributed: 31 third grade, 68 fourth grade, 60 fifth grade and 78 sixth grade. (Duration 5 months). Two follow-ups, at the beginning and end of the second academic semester, in March and in June-July.
Soysal et al. (2022)	To investigate temporal variations in the anxiety, motivation, and confidence levels of STEM (science, technology, engineering, and mathematics) students during the COVID-19 pandemic.	6-question questionnaire on anxiety, motivation, and confidence, following survey design best practices guided by Creswell (2011), DeVellis and Thorpe (2021), and Dillman et al. (2009).	53 STEM students who were enrolled in Calculus II and Calculus III courses during the COVID-19 pandemic in the summer of 2020 in the Department of Mathematics at the University of Missouri-Kansas City. (Duration 9 weeks).
Tomasetto et al. (2021)	To investigate whether MA interferes with MP in testing situations and early learning of mathematics, specifically the encoding of new mathematical knowledge, in elementary school children.	Tests of mathematical knowledge before and after a learning phase, and again after a one-week delay.	6-year-olds, in two studies: 115 in Italy, and 120 in the United Kingdom. (Duration 1 week), with tests administered immediately before and after the learning phase, and again after a one-week delay.
González et al. (2019)	To examine sex differences in neurobiological correlates of anxiety in STEM using the tripartite network model and its dysfunction in the context of clinical anxiety as a starting point	Self-report questionnaires to measure scientific, spatial, mathematical and clinical anxiety. In addition to resting-state functional magnetic resonance imaging (rs-fMRI) sessions to assess brain connectivity.	101 university physics students, 46 women. (Duration 15 weeks). Two moments: at the beginning of the semester ("pre-instruction") and at the end of the semester ("post-instruction").

Mathematics anxiety (MA) significantly impacts academic performance (MP) and mathematical skills. Longitudinal studies have demonstrated its negative association with MP, affecting areas such as calculation and counting, while also reducing children’s confidence in their mathematical abilities. O’Connor et al. (2023) showed that MA can be reliably measured as early as ages 7–8, and that early symbolic skills are key predictors of both MP and MA. The learning environment is also crucial. In this regard, Gashaj et al. (2023) emphasized that informal numerical activities at home mitigate the effects of MA on mathematical development, while Lichtenfeld et al. (2023) highlighted that positive emotions, such as joy, enhance MP, whereas negative emotions—including MA—generate a detrimental cycle for academic development.

In adolescents, Kim et al. (2023) identified a significant social influence effect, whereby MA tends to align with peers’ levels. Among university students, particularly women, Soysal et al. (2022) noted that the pandemic exacerbated MA, reducing motivation and confidence. In younger children, Tomasetto et al. (2021) found that MA hinders the encoding of new content, creating cumulative gaps.

Furthermore, González et al. (2019) explored gender differences in the neurobiological correlates of MA, finding that women report higher levels of STEM-related anxiety, although brain correlations were more pronounced in men.

Evidence from mixed-methods studies on MA

To analyze the impact of methodological diversity, publications employing a mixed-methods approach were reviewed, as such designs generate more comprehensive insights compared to previous studies. **Table 5** provides a summary of the publications using a mixed-methods approach.

Table 5. Summary of publications employing a mixed-methods approach

Author	Objective	Qualitative Method	Quantitative Method
Wahyuni et al. (2024)	To determine the effect of MA and self-confidence on geometry problem-solving skills. Explore student geometry problem-solving based on their MA level and self-confidence.	Semi-structured interviews, focused on problem solving.	Likert questionnaire (1-4) of 15 items (Juniati and Budayasa)
Ersozlu et al. (2022)	To explore and understand the causes and resources of AM among pre-service teachers and to suggest some intervention strategies to reduce such anxiety in early teacher education systems	Semi-structured questions, thematic analysis with Voyant. Categorize (negative experiences, fear of failure, pressure to exams).	Scales of self-perception of MA and mathematical knowledge; Descriptive and comparative analysis by gender.
Ellianawati et al. (2021)	To analyze students' reasoning skills and reduction of MA in analogy-based physics learning.	Questionnaires on attitudes and perceptions; Observations in class.	Pre/post intervention reasoning tests; MA scales.
Khasawneh et al. (2020)	To investigate the correlation between AM, numerical ability, and ability to perform medication calculations in paramedical students.	Semi-structured interviews	MARS Questionnaire; Numerical Skills and Medication Calculation (NAT) Tests

Recent studies on mathematics anxiety (MA) employ mixed methods approaches to analyze affective and cognitive factors influencing mathematical learning and performance. Khasawneh et al. (2020) noted that although technology can be useful, it may also foster mental laziness, whereas constant practice enhances mathematical competence. However, MA produces cognitive blocks that hinder calculation processes. Quantitatively, third-year students demonstrated better performance and lower MA than second-year students, with no significant gender differences.

Ellianawati et al. (2021) showed that analogy-based learning improves reasoning and reduces MA across three dimensions: tasks (-21.76%), classroom (-32.87%), and future (-18.29%). Similarly, Ersozlu et al. (2022) found a negative correlation between MA and perceived mathematical knowledge, identifying sources such as fear of failure, exam pressure, and lack of time. Wahyuni et al. (2024) reported that MA negatively affects geometric problem solving, while self-confidence exerts a positive effect, jointly explaining 22.6% of the variability in this skill.

Although combining qualitative and quantitative methods provides a more detailed perspective, these studies face common limitations, including small sample sizes, data biases, and lack of generalizability. This highlights the need to expand research across diverse cultural contexts and with larger sample sizes.

Findings from the Bibliometric Analysis

The bibliometric analysis was based on the analysis of numerical data obtained from the Scopus, Web of Science (WOS), and ERIC databases. A descriptive approach was employed, using publication counts and their classification by five-year periods, subject areas, countries of origin, authors, and institutions. The data were represented graphically to identify temporal, geographical, and thematic patterns.

Growth of publications on MA

Since the year 2000, research on mathematics anxiety (MA) has shown sustained growth in publications, according to the Scopus (346), WOS (140), and ERIC (379) databases. ERIC leads in the number of publications with 346, reflecting its stronger presence in MA-related topics. The significant increase beginning in the 2000–2005 period coincides with advances in research and greater awareness of MA in educational contexts.

The temporal analysis showed that the period 2020–2024 represents the highest peak of publications, suggesting a growing interest within the scientific community. This pattern underscores the importance of MA as an emerging topic in education and psychology, offering fertile ground for future research. **Figure 3** presents the number of publications by five-year periods with the title “Math anxiety” or “Mathematics anxiety” in the Scopus, Web of Science, and ERIC databases.

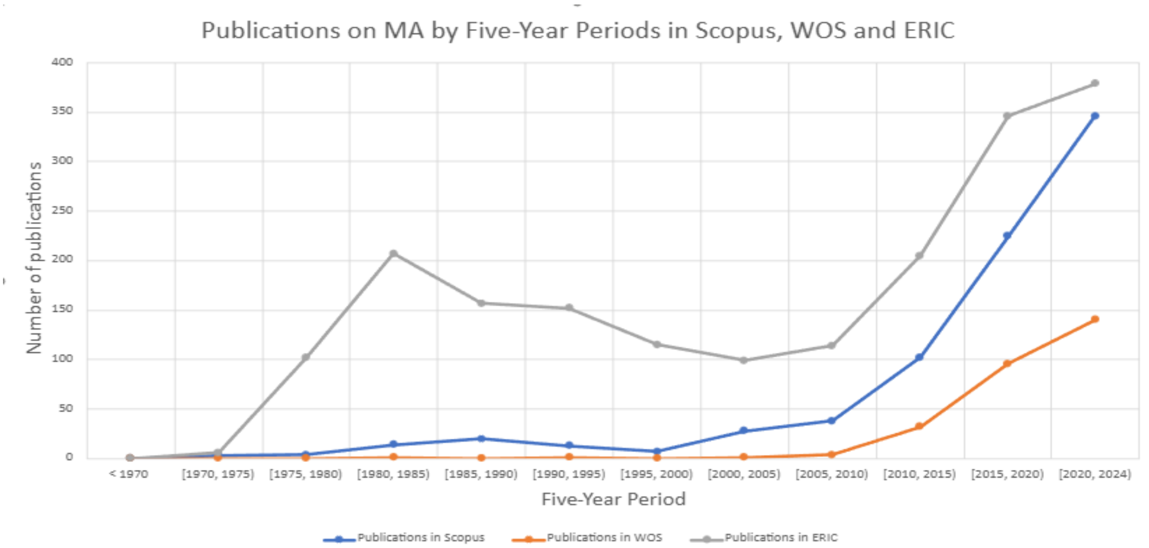

Figure 3. Publications on MA by five-year periods in Scopus, WOS, and ERIC (Source: Author’s own elaboration)

Geographic distribution of publications

The geographic distribution was analyzed through a ranking based on absolute publication counts by country, allowing the identification of regional trends and disparities. Regarding countries of origin, the United States leads MA research (210 publications), followed by the United Kingdom (70), China (47), Australia (40), Germany (40), and Canada (30), reflecting a predominance of North America and Asia. The presence of Italy (26) and Spain (35) indicates a global interest in the study of MA. These geographic differences suggest a potential for fostering international collaborations that integrate diverse perspectives and methodologies.

Prominent authors and institutions

Among prominent authors, Beilock (20 publications) and Maloney (17 publications) stand out as leading figures in the field. Institutions such as the University of California (35) and the University of Barcelona (26) lead in MA-related publications. These affiliations provide valuable resources for researchers seeking to deepen their expertise in the topic. The data were extracted and classified by institutional affiliation and frequency of appearance across the consulted databases, offering key information for scholars interested in identifying reference points in the area.

Types of publications and thematic areas

In terms of publication types, 82.8% correspond to peer-reviewed scientific articles, reflecting a preference for disseminating original research. A smaller proportion corresponds to reviews (4.3%) and book chapters (2.6%), which are essential for consolidating prior knowledge. The predominant thematic areas of publications include psychology, social sciences, and education, with relevant contributions from neuroscience and biochemistry. This interdisciplinary focus highlights the complexity of MA and the need to address it from multiple perspectives. **Figure 4** illustrates the thematic areas related to MA according to Scopus.

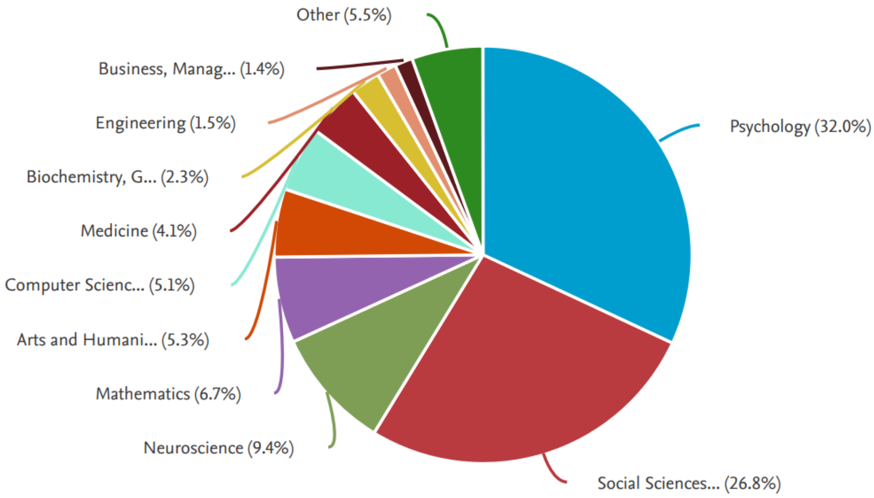

Figure 4. Thematic areas related to MA according to Scopus, search results analysis, retrieved on 07/08/2024 (Source: Author's own elaboration)

Funding and sponsorship

The National Science Foundation (NSF) and the National Institutes of Health (NIH) are the main sponsors of research on MA (28 and 35 publications, respectively), reflecting an interdisciplinary focus across education, health, and social sciences. International institutions such as the National Natural Science Foundation of China and the European Union also actively support these studies, underscoring the global importance of the issue. The participation of both private and public foundations ensures stability and diversity in MA research.

Summary of Findings

In sum, the evidence reviewed indicates that mathematics anxiety has been conceptualized in multiple ways, ranging from a stable trait or a situational state to a multidimensional phenomenon encompassing cognitive, emotional, and social factors (Dyulicheva, 2021; Finell et al., 2022; González et al., 2019; Khasawneh et al., 2020). Methodologically, cross-sectional designs and standardized scales such as MARS and AMAS predominate, though their cross-cultural validity and ability to capture the dynamic nature of MA remain limited; longitudinal studies (Lichtenfeld et al., 2023) and mixed-methods approaches are growing but still constrained by cost and complexity. Key trends include a shift toward neurocognitive and physiological models, interest in innovative interventions like project-based learning and gamification, and greater attention to motivational and teacher-related factors. Persistent gaps involve insufficient exploration of socioeconomic and cultural variables, limited long-term intervention studies, and a lack of consensus on measurement standardization.

DISCUSSION AND CONCLUSIONS

The present review reaffirms core findings from earlier syntheses (Hembree, 1990; Zhang et al., 2019), particularly the consistent negative association between MA and performance and the persistence of gender differences. However, it extends those findings by highlighting that recent work increasingly identifies working memory as a mediator (Finell et al., 2022) and early symbolic skills as protective factors (O'Connor et al., 2023). Moreover, while the methodological landscape remains dominated by cross-sectional self-report scales, the growing incorporation of longitudinal and mixed-methods designs signals a maturing field that is better equipped to capture the dynamic and context-dependent nature of MA.

With respect to the limitations of the present review, it is worth noting that the inclusion of open-access publications may have excluded relevant restricted-access research. Similarly, the temporal delimitation (2019–2024) excludes prior studies that could have enriched the current trends. Another limitation is the use of only three databases (Scopus, WOS, and ERIC), which, although highly recognized, omit literature published in regional databases or in other disciplines. Additionally, the bibliometric analysis could not be fully applied to ERIC due to the lack of built-in analytical tools in that database, which may slightly affect the comprehensiveness of the quantitative indicators.

The findings underscore several implications for both research and practice. On the one hand, future studies should prioritize the development of replicable interventions adaptable across educational levels, and the integration of physiological and genetic measures with traditional scales to enhance reliability. On the other hand, practitioners and policymakers would benefit from early, evidence-based programs that strengthen foundational numerical skills and emotional regulation, thereby counteracting the self-perpetuating cycle of MA. Furthermore, the promotion of international collaborations and the dissemination of culturally adapted instruments in open-access journals would facilitate cross-cultural comparisons and broaden the practical impact for teachers, psychologists, and policymakers.

In conclusion, this review of 28 recent publications shows that mathematics anxiety is now consistently approached as a multidimensional construct, benefiting from increasingly diverse methodologies that go beyond traditional self-reports. The field is moving toward interdisciplinary models that connect neurocognitive, affective, and contextual factors. By identifying both persistent limitations and emerging opportunities, this work provides a structured foundation for future studies and reinforces the link between theoretical development and practical application in the field of mathematics anxiety.

Beyond the diversity of definitions and methodological approaches identified in the literature, the evidence reviewed suggests a gradual shift in the understanding of mathematics anxiety from a predominantly emotional construct toward a multidimensional phenomenon that emerges from the interaction of cognitive, affective, social, and contextual factors. Early studies tended to conceptualize mathematics anxiety as an individual reaction to mathematical tasks, whereas recent research increasingly highlights the role of working memory, self-efficacy, peer influence, family environments, cultural contexts, and educational practices. This evolution reflects a broader movement in educational psychology toward systemic explanations of learning processes, where mathematics anxiety is no longer viewed solely as a personal deficit but as the result of dynamic interactions between learners and their educational environments. Consequently, effective interventions may require integrated approaches that simultaneously address emotional regulation, cognitive development, and contextual conditions that shape students' experiences with mathematics.

An emerging implication of the reviewed evidence is that mathematics anxiety may be better understood as an educational ecosystem variable rather than as an isolated psychological trait. The recurring appearance of contextual influences—including teachers' attitudes, family environments, peer networks, classroom practices, and sociocultural expectations—suggests that mathematics anxiety develops and evolves within relational systems. This perspective opens new research directions focused on understanding how educational environments contribute to the amplification or reduction of anxiety trajectories over time. Such an approach may facilitate the design of preventive interventions aimed not only at students but also at the broader educational contexts in which mathematical learning occurs.

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Ethical statement: The authors stated that the study is a systematic review and bibliometric analysis of previously published literature. It does not involve primary data collection from human participants, animals, or sensitive personal data. Therefore, ethical approval from an institutional review board was not required, and informed consent was not applicable. All data used in this study were obtained from publicly available academic databases (e.g., Web of Science, Scopus) and were analysed in an aggregated and anonymized manner, ensuring no confidential or personal information was handled.

AI statement: The authors stated that generative artificial intelligence was used to perform some preliminary searches in the early stages of the study. Notebook LM was also used to check that all cited material was properly referenced.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition and Emotion, 8*(1), 97-125. https://doi.org/10.1080/02699939408408931

Balt, M., Börnert-Ringleb, M., & Orbach, L. (2022). Reducing math anxiety in school children: A systematic review of intervention research. *Frontiers in Education, 7*, Article 798516. https://doi.org/10.3389/feduc.2022.798516

Creswell, J. W. (2011). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson.

Daches Cohen, L., Korem, N., & Rubinsten, O. (2021). Math anxiety is related to math difficulties and composed of emotion regulation and anxiety predisposition: A network analysis study. *Brain Sciences, 11*(12), Article 1609. https://doi.org/10.3390/brainsci11121609

DeVellis, R. F., & Thorpe, C. T. (2021). *Scale development: Theory and applications*. SAGE.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed- mode surveys: The tailored design method*. John Wiley & Sons, Inc.

Dreger, R. M., & Aiken, L. R. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology, 48*(6), 344-351. https://doi.org/10.1037/h0045894

Dyulicheva, Y. Y. (2021). Learning analytics in MOOCs as an instrument for measuring math anxiety. *Voprosy Obrazovaniya / Educational Studies Moscow*, (4), 243-265. https://doi.org/10.17323/1814-9545-2021-4-243-265

Ellianawati, E., Subali, B., Khotimah, S. N., & Cholila, M. (2021). Profile of reasoning ability and reduction of mathematical anxiety in analogy-based physics learning. *Journal of Physics: Conference Series*, *1918*(1), 052051. https://doi.org/10.1088/1742-6596/1918/5/052051

Ersozlu, Z., Blake, D., Usak, M., & Hawken, S. (2022). Addressing preservice teacher's reasons for mathematics and test anxiety. *European Journal of Educational Research, 11*(3), 1715-1728. https://doi.org/10.12973/eu-jer.11.3.1715

Finell, J., Sammallahti, E., Korhonen, J., Eklöf, H., & Jonsson, B. (2022). Working memory and its mediating role on the relationship of math anxiety and math performance: A meta-analysis. *Frontiers in Psychology*, *12*, Article 798090. https://doi.org/10.3389/fpsyg.2021.798090

Gashaj, V., Thaqi, Q., Mast, F. W., & Roebers, C. M. (2023). Foundations for future math achievement: Early numeracy, home learning environment, and the absence of math anxiety. *Trends in Neuroscience and Education, 33*, Article 100217. https://doi.org/10.1016/j.tine.2023.100217

Girelli, L. (2023). What does gender have to do with math? Complex questions require complex answers. *Journal of Neuroscience Research, 101*(5), 679-688. https://doi.org/10.1002/jnr.25056

González, A. A., Bottenhorn, K. L., Bartley, J. E., Hayes, T., Riedel, M. C., Salo, T., Bravo, E. I., Odean, R., Nazareth, A., Laird, R. W., Sutherland, M. T., Brewe, E., Pruden, S. M., & Laird, A. R. (2019). Sex differences in brain correlates of STEM anxiety. *NPJ Science of Learning, 4*(1), Article 18. https://doi.org/10.1038/s41539-019-0058-9

Gough, M. F. (1954). Mathemaphobia: Causes and treatments. *Clearing House*, *28*(6), 290-294.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46. https://doi.org/10.2307/749455

Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS) construction, validity, and reliability. *Assessment*, *10*(2), 178-182. https://doi.org/10.1177/1073191103010002008

Khasawneh, E., Gosling, C., & Williams, B. (2020). The correlation between mathematics anxiety, numerical ability and drug calculation ability of paramedic students: An explanatory mixed method study. *Advances in Medical Education and Practice*, *11*, 869-878. https://doi.org/10.2147/AMEP.S258223

Khasawneh, E., Gosling, C., & Williams, B. (2021). What impact does maths anxiety have on university students? *BMC Psychology, 9*, Article 37. https://doi.org/10.1186/s40359-021-00537-2

Kim, J., Shin, Y.-J., & Park, D. (2023). Peer network in math anxiety: A longitudinal social network approach. *Journal of Experimental Child Psychology*, *232*, Article 105672. https://doi.org/10.1016/j.jecp.2023.105672

Lazarus, M. (1974). Mathophobia: Some personal speculations. *National Elementary Principal, 53*(4), 16-22.

Lichtenfeld, S., Pekrun, R., Marsh, H. W., Nett, U. E., & Reiss, K. (2023). Achievement emotions and elementary school children's academic performance: Longitudinal models of developmental ordering. *Journal of Educational Psychology, 115*(4), 552-570. https://doi.org/10.1037/edu0000748

Lukowski, S. L., DiTrapani, J. B., Jeon, M., Wang, Z., Schenker, V. J., Doran, M. M., Hart, S. A., Mazzocco, M. M. M., Willcutt, E. G., Thompson, L. A., & Petrill, S. A. (2019). Multidimensionality in the measurement of math-specific anxiety and its relationship with mathematical performance. *Learning and Individual Differences*, *70*, 228-235. https://doi.org/10.1016/j.lindif.2016.07.007

Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology Research and Behavior Management*, *11*, 311-322. https://doi.org/10.2147/PRBM.S141421

Megreya, A. M., Al-Emadi, A. A., & Moustafa, A. A. (2022). The Arabic version of the modified-abbreviated math anxiety scale: Psychometric properties, gender differences, and associations with different forms of anxiety and math achievement. *Frontiers in Psychology*, *13*, Article 919764. https://doi.org/10.3389/fpsyg.2022.919764

O'Connor, P. A., Morsanyi, K., & McCormack, T. (2023). Basic symbolic number skills, but not formal mathematics performance, longitudinally predict mathematics anxiety in the first years of primary school. *Journal of Intelligence, 11*(11), Article 211. https://doi.org/10.3390/jintelligence11110211

Orbach, L., & Fritz, A. (2022). Patterns of attention and anxiety in predicting arithmetic fluency among school-aged children. *Brain Sciences, 12*(3), Article 376. https://doi.org/10.3390/brainsci12030376

Page, M. J, McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S.… Moher, D. (2021). PRISMA 2020 statement: An updated guide to the publication of systematic reviews. *BMJ*, *372*, Article n71. https://doi.org/10.1136/bmj.n71

Pizzie, R. G., & Kraemer, D. J. M. (2019). The Academic Anxiety Inventory: Evidence for dissociable patterns of anxiety related to math and other sources of academic stress. *Frontiers in Psychology, 9*, Article 2684. https://doi.org/10.3389/fpsyg.2018.02684

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement, 42*(2), 551-557.

Ribeiro, T. A., & Carmo, J. dos S. (2024). Estratégias de Redução da Ansiedade Matemática: uma revisão sistemática da literatura [Strategies for math anxiety reduction: A systematic literature review]. *Bolema: Mathematics Education Bulletin*, *38*, Article e230007. https://doi.org/10.1590/1980-4415v38a230007

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554.

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions, 6*(1), Article 46. https://doi.org/10.1186/1744-9081-6-46

Schmitz, E. A., Jansen, B. R. J., Wiers, R. W., Salemink, E. (2019). Do implicitly measured math-anxiety associations play a role in math behavior? *Journal of Experimental Child Psychology, 186*, 171-188. https://doi.org/10.1016/j.jecp.2019.05.013

Song, C. S., Xu, C., Maloney, E. A., Skwarchuk, S.-L., Di Lonardo Burr, S., Lafay, A., Wylie, J., Osana, H. P., Douglas, H., & LeFevre, J. (2021). Longitudinal relations between young students' feelings about mathematics and arithmetic performance. *Cognitive Development*, *59*, Article 101078. https://doi.org/10.1016/j.cogdev.2021.101078

Soysal, D., Bani-Yaghoub, M., & Riggers-Piehl, T. A. (2022). Analysis of anxiety, motivation, and confidence of STEM students during the COVID-19 pandemic. *International Electronic Journal of Mathematics Education, 17*(2), Article em0684. https://doi.org/10.29333/iejme/11836

Szczygieł, M. (2019). How to measure math anxiety in young children? Psychometric properties of the modified Abbreviated Math Anxiety Scale for Elementary Children (mAMAS-E). *Polish Psychological Bulletin, 50*(4), 303-315. https://doi.org/10.24425/ppb.2019.131003

Szczygieł, M. (2020). More evidence that math anxiety is specific to math in young children: The correlates of the Math Anxiety Questionnaire for Children (MAQC). *International Electronic Journal of Elementary Education, 12*(5), 429-438. https://doi.org/10.26822/iejee.2020562133

Taylor, B. A., & Fraser, B. J. (2013). Relationships between learning environment and mathematics anxiety. *Learning Environments Research, 16*(2), 297-313. https://doi.org/10.1007/s10984-013-9134-x

Tobias, S. (1978). *Overcoming math anxiety.* Houghton Mifflin.

Tomasetto, C., Morsanyi, K., Guardabassi, V., & O'Connor, P. A. (2021). Math anxiety interferes with learning novel mathematics contents in early elementary school. *Journal of Educational Psychology, 113*(2), 315-329. https://doi.org/10.1037/edu0000602

Van der Ven, S. H. G., Prast, E. J., & Van de Weijer-Bergsma, E. (2023). Towards an integrative model of math cognition: Interactions between working memory and emotions in explaining children's math performance. *Journal of Intelligence, 11*(7), Article 136. https://doi.org/10.3390/jintelligence11070136

Wahyuni, R., Juniati, D., & Wijayanti, P. (2024). How do math anxiety and self-confidence affect mathematical problem solving? *TEM Journal, 13*(1), 550-560. https://doi.org/10.18421/TEM131-58

Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology, 10*, Article 1613. https://doi.org/10.3389/fpsyg.2019.01613