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Mathematics anxiety in primary education: A systematic review of foundations, causes, and interventions

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Abstract

Mathematics anxiety (MA) is a common issue in primary education, negatively impacting students' academic performance, motivation, and confidence in mathematics. This study addresses existing gaps by systematically analyzing global trends, theoretical foundations, causes, and effective interventions for MA. A systematic literature review (SLR) was conducted using PRISMA guidelines, which included the stages of identification, screening, eligibility, and inclusion. Articles analyzed from the Scopus database were published between 2014 and 2024. The findings reveal a significant rise in MA research in recent years, with major contributions from China and the UK. Key theoretical foundations include anxiety and cognitive load theories, emphasizing the interplay between emotional and cognitive factors in MA development. Major causes of MA include cognitive limitations, gender, and curriculum. Effective interventions involve pedagogical approaches, psychological strategies, teacher support, and technology integration. These approaches include active learning, mindfulness techniques, and the use of interactive digital tools. This study highlights the importance of collaboration among educators, policymakers, and researchers to mitigate MA's impact and foster positive mathematical experiences for primary school students.

Keywords: systematic review; mathematics anxiety; elementary education; primary education

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I. Introduction

Mathematics plays a central role in primary education because it serves as a foundation for the development of students' logical thinking, problem-solving, and numeracy literacy skills (Kim & Albert, 2015; Medeiros & Alberto, 2022; Vragović & Klasnić, 2021). These skills are important for students' academic success and prepare them for challenges in their daily lives and future careers (Kvesic et al., 2020; Panjaitan & Zuhri, 2020; Rodríguez et al., 2020). However, for some students, mathematics is a source of stress and anxiety, known as mathematics anxiety (MA) (Rada & Lucietto, 2022; Villavicencio & Bernardo, 2016; Zanabazar et al., 2023). This condition can affect learning motivation and self-confidence and significantly reduce academic performance (Ali & Hassan, 2019; Wahid et al., 2018; Zhang et al., 2019).

Mathematics anxiety is a specific form of anxiety characterized by excessive fear when facing mathematical tasks, both formally in class

and in everyday life (Beilock & Maloney, 2015; Finlayson, 2014). Studies show that MA often appears early and can have long-term impacts on students' ability to learn mathematics at higher levels (Anindyarini, 2019; Cargnelutti et al., 2017). Therefore, addressing MA since primary education is important to ensure that the mathematics learning process is effective and inclusive (Balt et al., 2022; Cargnelutti et al., 2017; Tomasetto et al., 2021).

Although studies on MA have been conducted for decades, there are still challenges in understanding the causes and effective solutions to overcome this phenomenon, especially at the primary education level (Balt et al., 2022; Ersozlu & Karakus, 2019; Gelcich et al., 2014; Prasetyo et al., 2023). Many studies only focus on symptoms or impacts, while systematic exploration of broader global research trends, such as geographic distribution, key keywords, and journals supporting this research, is still limited (Balt et al., 2022). In addition, theoretical studies on the causes of MA are often limited to internal factors, such as low self-confidence or negative experiences with mathematics (Finlayson, 2014). External factors, such as teaching methods, teacher roles, and parental expectations, also play an important role in shaping students' levels of anxiety towards mathematics (Li et al., 2023; Ober & Cheng, 2021; Prasetyo et al., 2023; Rubinsten et al., 2018). An incomplete understanding of these causes can hamper efforts to design effective interventions.

Previous research also shows gaps in research trends. Systematic analysis of the geographical distribution of research frequently used keywords and journals and citation rates have not been widely conducted, especially at the primary education level (Dowker et al., 2004). This mapping is important for understanding the global focus in research on MA. In addition, although various interventions to reduce MA have been developed, such as psychological approaches and classroom-based strategies, empirical evidence on their effectiveness is still limited and fragmented (Ersozlu & Karakus, 2019). Studies that integrate the results of these interventions in the context of primary education are still needed to provide evidence-based recommendations.

This study aims to fill these gaps by presenting a systematic review of mathematics anxiety in primary education. Specifically, this study analyzes current research trends, including geographical distribution, key keywords, leading journals, and citation rates in research on MA. In addition, this study also aims to map the main factors that cause MA, both from an internal perspective and an external perspective. By understanding these causes, the study is expected to help design more appropriate strategies to overcome MA. This study also analyzes various interventions implemented to reduce MA at the primary education level. The results of this study are expected to provide practical contributions for teachers and policymakers to improve the quality of mathematics learning in primary schools and provide directions for further research.

II. Research Method

This study uses the Systematic Literature Review (SLR) method, documented with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagrams. The PRISMA framework guides this systematic review, a general guideline widely used in systematic literature reviews, critical literature analysis, and meta-analyses. The PRISMA framework is widely accepted as a standard for assessing the quality and validity of systematic reviews. PRISMA, introduced by Moher et al. (2009), has become the primary guideline in many studies because of its validity and methodological suitability. Journals that adopt PRISMA tend to have better methodological and reporting quality than journals that do not support it in the same period (Asikin et al., 2023; Moher et al., 2009; Panic et al., 2013).

In this literature review, we followed the PRISMA approach generated from the Watase Uake Tools System (Hariningsih et al., 2024)

with the following steps: (1) Identifying relevant keywords, inclusion criteria, and limitations, (2) Filtering relevant articles based on these criteria, (3) Searching for articles from selected sources, (4) Reading the title, abstract, and keywords of the screened articles, (5) Filling in the main items of each selected article in the data extraction process, and (6) Conducting classification analysis, network analysis, and data visualization.

Question Formulation

Formulating research questions is important to determine a clear scope and focus of the research so that the research conducted is more focused and systematic (Asikin, et al., 2023; Husamah et al., 2022b). This study aims to identify research on mathematics anxiety in primary education. Therefore, this study poses and attempts to answer questions that are relevant to the subject matter. The formulation of these questions comes from the specific requirements of the selected topic: First, what are the current research trends on mathematics anxiety in primary education? (RQ1). Second question: What are the main theoretical foundations of mathematics anxiety in primary education? (RQ2). Third question: What factors cause mathematics anxiety in primary education? (RQ3). Fourth question: What interventions are carried out to reduce mathematics anxiety in primary education? (RQ4).

Study Selection (Inclusion and Exclusion Criteria)

Study selection was conducted to include and exclude published articles relevant to the research. In this study, the Scopus database was selected because of its strict indexing quality and high number of citations (Aghaei et al., 2013; Husamah et al., 2022a; Lasda, 2012; Nurwidodo et al., 2023). We used the keywords 'math anxiety' AND 'primary education.' Based on the PRISMA reporting generated from Watase uake tools (Figure 1), we obtained 20 articles that met the criteria in this SLR study. The following are the key points that form the basis of the inclusion and exclusion criteria that we use in this SLR, namely: 1) only papers published in scientific journals, 2) articles published in the Scopus Q1–Q4 database, 3) articles published between 2014 and 2024, 4) articles in English. Scopus is a widely recognized and reputable database known for its rigorous indexing standards and established metrics, including quartile rankings (Q1–Q4) (Aghaei et al., 2013; Lasda, 2012). Its comprehensive coverage of peer-reviewed scientific literature ensures access to high-quality research with strong citation metrics (Falagas et al., 2008; Hariningsih et al., 2024). The database's stringent journal selection process further enhances its reliability, making it an ideal resource for scholarly studies.

Search Procedure

The research process consisted of four main stages: identification, screening, eligibility, and inclusion, which aimed to evaluate the literature on mathematics anxiety in primary education. In the identification stage, the search resulted in 38 articles, of which 2 articles were excluded because they did not meet the eligibility criteria based on the year of publication (2014–2024) and journal tier (Q1–Q4). After this removal, 36 articles were screened for further processing. In the screening stage, 36 articles were evaluated through abstracts and titles, resulting in the removal of 11 articles that were considered irrelevant. Of the 25 remaining articles for the next stage, 7 were inaccessible because they did not meet the inclusion criteria. In addition, manual searching through alternative methods resulted in 8 additional articles.

The eligibility stage involved the evaluation of 18 articles that met the criteria, of which 5 articles were excluded due to incompatibility with the research focus. Of the additional articles obtained from other methods, all 8 articles were assessed and deemed eligible. At the inclusion stage, a total of 13 primary studies from the Scopus database and 7 additional studies from other sources were included in the systematic review, resulting in a total of 20 articles. This process ensured that the literature used was relevant, of high quality, and by the research objectives. The methods applied reflected a transparent and structured approach to ensure the validity of the Results. Through various stages of rigorous selection, this study provides a strong foundation for an in-depth

analysis of trends, theoretical foundations, causal factors, and interventions related to mathematics anxiety in primary education.

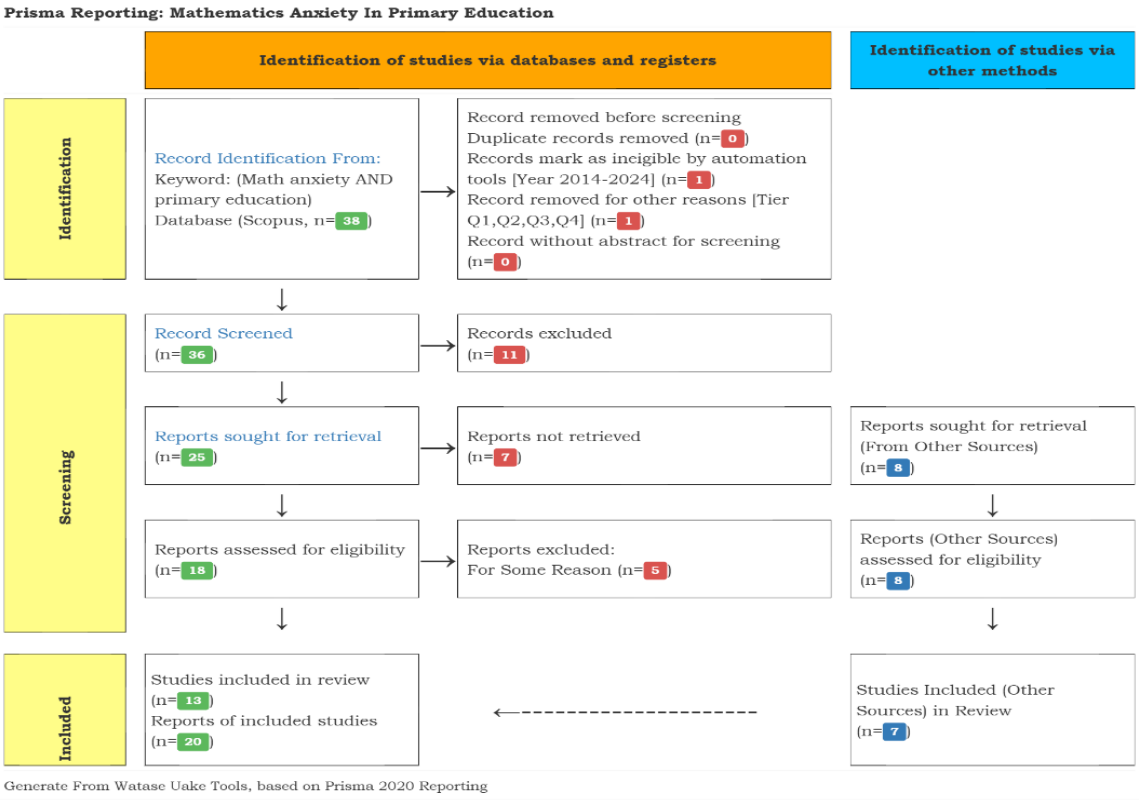

Figure 1. The PRISMA stages consist of identification, screening, and inclusion

Based on the distribution data for the year of the article, it can be seen how the research trend on mathematics anxiety in primary education developed from 2015 to 2024 (Figure 2). This data trend reflects the increasing attention to mathematics anxiety in recent years, especially in 2024, which showed a significant spike with 7 articles. This increase can be attributed to various factors, such as the increasing global awareness of the importance of addressing mathematics anxiety at an early age, as this phase is the foundation for further mathematics learning (Möhring et al., 2024; Tomasetto et al., 2021). In addition, educational policies that increasingly encourage inclusivity and approaches based on students' emotional well-being have also encouraged research in this area.

III. Results and Discussion

The results and discussion section provides an explanation to answer the research questions, including research trends, theoretical basis, causal factors, and interventions provided to reduce students' mathematics anxiety in primary education.

Research Trends (Q1: What are the current research trends on mathematics anxiety in primary education?)

Mathematics anxiety is a psychological phenomenon that continues to be a major concern in the world of education, especially at the primary education level. This anxiety not only affects students' academic abilities but also shapes their perception of mathematics as a difficult subject, which can impact career choices and future learning interests.

Distribution Year

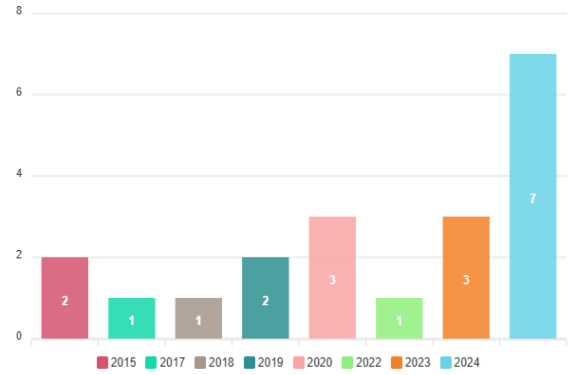

Figure. 2. The article's year of distribution

The decline in 2017 and 2018 reflects the limited research focus on other areas. However, the spike in 2020 can be attributed to technological educational innovations that have spurred research on digital-based intervention strategies to address mathematics anxiety (Chen, 2019). The significant increase in 2024 could be due to the recovery from the COVID-19 pandemic that has provided an impetus for researchers to explore the impact of the pandemic on students' mathematics anxiety, as well as efforts to find new, more effective intervention strategies (González-Gómez et al., 2024; Lennon-Maslin et al., 2024; Xie et al., 2024).

This distribution also shows a change in the dynamics of global research, where issues related to students' mental and cognitive well-being are receiving greater attention in the context of primary education. Mathematics anxiety needs to be addressed early because it has a cumulative impact that affects students' learning achievement at the next level. Thus, this increasing trend reflects the urgency of the topic and global awareness to solve the problem of mathematics anxiety more systematically (Caviola, Carey, et al., 2017; Rada & Lucietto, 2022).

Keywords

Research trends related to mathematics anxiety in primary education can be identified by analyzing keywords frequently appearing in scientific publications (Figure 3). The most prominent keywords in research on mathematics anxiety in primary education are "math anxiety," "primary education," and "anxiety." These words indicate that the main focus of the research lies in the phenomenon of mathematics anxiety at the primary education level.

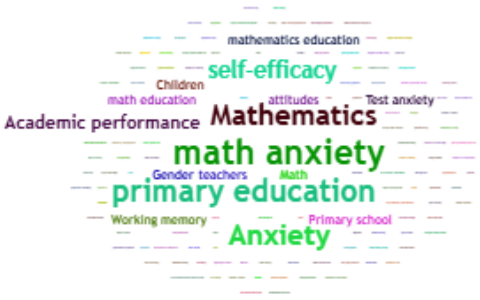

Figure 3: Word cloud created using Watase Uake tools based on keywords

This keyword analysis shows a current research trend focusing on mathematics anxiety's causes and impacts in primary education. The term "self-efficacy" indicates that students' confidence in their mathematics abilities is one of the factors that is often associated with anxiety levels. Self-efficacy plays an important role in influencing student motivation and performance (Luo et al., 2021; Pérez-Fuentes et al., 2020). In addition, low self-efficacy tends to have higher levels of mathematics anxiety (Guntur & Purnomo, 2024; Villavicencio & Bernardo, 2016).

In addition, the emergence of the term "academic performance" confirms that research on mathematics anxiety is often associated with students' academic performance. Mathematics anxiety has a negative relationship with academic performance, where students with high levels of anxiety tend to have difficulty understanding mathematical concepts and completing assignments (John & Estonanto, 2017; Zanabazar et al., 2023). The term "working memory" also emerged as one of the important keywords, indicating a link between students' working memory capacity and their ability to overcome mathematical challenges (Menon, 2016; Nur et al., 2018; Passolunghi et al., 2016).

The words "gender" and "teachers" indicate that there is research exploring the influence of external factors, such as the role of teachers and gender differences, on students' levels of mathematics anxiety (Arifin & Kismiantini, 2023; Doz et al., 2023; Hikmatul Maghfiroh et al., 2021; Xie et al., 2024). Positive

perceptions and teacher support can influence students' attitudes and anxiety in mathematics lessons (Ober et al., 2021; Ober & Cheng, 2021). With the emergence of the terms "primary education" and "primary school," the current research trend focuses attention on the primary education level as a crucial phase in the development of mathematics anxiety. Mathematics anxiety often appears at an early age and can have long-term impacts if not addressed promptly (Möhring et al., 2024; Sevinc, 2023; Szczygieł et al., 2024).

Author's Country

Research on mathematics anxiety in primary education has received global attention due to its significant impact on student learning. The pie chart data in Figure 4 shows the distribution of research on mathematics anxiety at the elementary education level according to the author's country of origin. The two countries that dominate research contributions are China and the UK, which have 15% of the total publications. Other countries such as Australia, Germany, and Indonesia each contribute 10%. The same contribution also comes from Italy, Poland, and Switzerland, with 5% each. In addition, countries such as Taiwan, Macau, Spain, and Sweden also contribute 5% of their research.

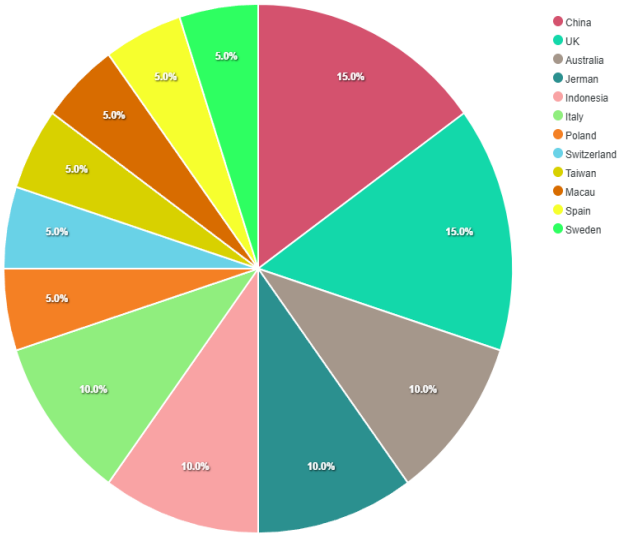

Figure 4: Authors' country distribution

The dominance of China and the UK in research related to mathematics anxiety shows that there is great attention to this issue in both countries. China, as a country with a competitive education system, shows an increase in research on the psychological aspects of students in mathematics subjects. Research from China often highlights the relationship between mathematics anxiety and students' academic performance and its impact on the outcome-oriented educational culture (Zhang et al., 2019). On the other hand, the UK has a long tradition of psychology-based educational research, focusing on factors such as self-efficacy, working memory, and effective psychological interventions to reduce mathematics anxiety (Caviola, Carey et al., 2017; Menon, 2016; Passolunghi et al., 2016; Pérez-Fuentes et al., 2020; Villavicencio & Bernardo, 2016).

Significant contributions from countries such as Australia, Germany, and Indonesia reflect the growing body of research on this issue across cultural contexts and educational systems. Research in Australia, for example, focuses more on applying inclusive teaching strategies and innovative learning approaches to reduce students' anxiety from an early age (Larkin & Jorgensen, 2016; Mavilidi et al., 2020). Meanwhile, in Germany, studies focus on cognitive aspects such as working memory and how anxiety affects students' numerical processing (Lennon-Maslin et al., 2024; Lennon-Maslin & Quaiser-Pohl, 2024). Indonesia, as one of the developing countries that contributes 10%, shows increasing attention to this issue, especially in the context of a national education system that often faces challenges such as low student numeracy literacy (Guntur & Purnomo, 2024; Supriadi et al., 2024). Studies in Indonesia have explored many external factors, such as teaching methods, the role of teachers, and parental support in influencing students' mathematics anxiety in primary education.

Most Citation Journal

Research on mathematics anxiety in primary education continues to develop in terms of publication volume and the contribution of journals with significant influence. Analysis of

Table 1. Most citation journal

Journal	Tier	Citation	Year	Author
Journal of Educational Computing Research	1	124	2019	Chen, 2019
International Journal of Science and Mathematics Education	1	71	201	Larkin & Jorgensen, 2016
International Journal of Environmental Research and Public Health	1	26	2020	Mavilidi et al., 2020
Royal Society Open Science	1	20	2019	Field et al., 2019
Sustainability	1	17	2020	Rodríguez et al., 2020
Scientific Reports	1	15	2018	Hartwright et al., 2018
Education Inquiry	1	12	2015	Nyroos et al., 2015
Journal of Research in Childhood Education	2	2	2023	Petronzi et al., 2024
Frontiers in Education	2	1	2024	Lennon-Maslin et al., 2024
Journal of Experimental Child Psychology	1	0	2024	Möhring et al., 2024

journals with the highest number of citations helps identify scientific publication centers that play a role in disseminating knowledge related to this topic. High-reputation journals are an important indicator in seeing the credibility of research and its influence in the scientific community.

The data presented in Table 1 includes a list of top journals based on the number of citations, rank, and year of publication, which provides an overview of current trends in mathematics anxiety research.

Based on the review analysis results, the journal with the highest citations is the Journal of Educational Computing Research, which has 124 citations in an article published in 2019 by Chen (2019). Furthermore, the International Journal of Science and Mathematics Education is in second place with 71 citations in an article published in 2016 by Larkin and Jorgensen (2016). The third position is occupied by the International Journal of Environmental Research and Public Health, with 26 citations for an article published in 2020 by Mavilidi et al. (2020). Other journals, such as Royal Society Open Science (20 citations), sustainability (17 citations), and Scientific Reports (15 citations), showed significant influence in disseminating related research findings. Meanwhile, tier 2 journals such as the Journal of Research in Childhood Education and Frontiers in Education had lower citations, with 2 and 1 citations. The latest article in 2024 from the Journal of Experimental Child Psychology has no citations because it was just published.

The dominance of tier 1 journals in this list shows that research related to mathematics anxiety tends to be published in journals with high reputations and high influence in the fields of education and psychology. The article with the highest number of citations by Chen (2019), The Journal of Educational Computing Research, shows that technology in mathematics education is an important topic in overcoming mathematics anxiety. This study discusses the effectiveness of technology and digital-based learning media in improving mathematics understanding and reducing student anxiety.

Research by Larkin & Jorgensen (2016) The International Journal of Science and Mathematics Education highlights pedagogical approaches to dealing with mathematics anxiety through inclusive and interactive teaching methods. This study underlines the importance of teachers' role in building students' self-confidence in mathematics classes from an early

age. Meanwhile, the contribution of Mavilidi et al. (2020), The International Journal of Environmental Research and Public Health, emphasizes the relationship between physical activity and decreased mathematics anxiety, showing an innovative approach that combines learning and students' mental health.

Articles from the Royal Society Open Science and Scientific Reports journals focus more on cognitive aspects, such as the role of working memory and brain function in overcoming mathematics anxiety (Field et al., 2019; Hartwright et al., 2018). These results show that research related to mathematics anxiety is multidisciplinary, combining education, psychology, and neuroscience to understand the mechanisms that cause anxiety and intervention strategies.

Mathematics Anxiety Instrument

Measuring MA is a crucial aspect of research because the instrument used plays a role in determining the data's accuracy and the research results' relevance. Based on our review and analysis in Table 2, the Abbreviated Math Anxiety Scale (AMAS) instrument dominates with the highest use of 5 times. It has 149 citations, indicating its relevance and reliability as a frequently used measurement tool.

Table 2. Mathematics anxiety instrument

Mathematics Anxiety Instrument	Count	Citation
Abbreviated Math Anxiety Scale (AMAS)	5	149
Cognitive Anxiety Test Questionnaire (CATQ)	1	26
Math Anxiety Scale (Math-AS)	1	15
Children's Test Anxiety Scale (CTAS)	1	12
Children's Math Anxiety Scale (CMAS-UK)	1	2
Child Spatial Anxiety Questionnaire (CSAQ)	1	1
The German version of the math anxiety questionnaire (GMAQ)	1	0
Modified Abbreviated Math Anxiety Scale (MAMAS)	1	0
Mathematics Anxiety Scale for Children (MASC)	1	0
Children's Mathematical Anxiety Scale (CMAS)	1	0
Abbreviated Math Anxiety Scale (AMAS)	1	0
Modified Abbreviated Math Anxiety Scale for Elemen (MAMASE)	1	0
Revised Abbreviated Math Anxiety Scale (RAMAS)	1	0
Mathematics Anxiety Scale (MAS)	1	0

Meanwhile, other instruments, such as the Cognitive Anxiety Test Questionnaire (CATQ), have 1 use with 26 citations, followed by the Math Anxiety Scale (Math-AS) with 15 citations, and the Children's Test Anxiety Scale (CTAS), which recorded 12 citations. Other instruments, such as the Children's Math Anxiety Scale (CMAS-UK), the Child Spatial Anxiety Questionnaire (CSAQ), and modified-based instruments, such as the Modified Abbreviated Math Anxiety Scale (MAMAS) and the Revised Abbreviated Math Anxiety Scale (RAMAS), have each only been used once and most have not been cited.

The dominance of the AMAS as an MA measurement instrument indicates that this scale is the main choice of researchers because of its concise, valid, and reliable nature. The AMAS was developed by Hopko et al. (2003) and has been widely used to measure mathematics anxiety in various age groups, including elementary school students. The use of the AMAS reflects a research trend that prioritizes short but effective instruments in capturing the emotional and cognitive aspects of mathematics anxiety. With 149 citations, the AMAS has become an instrument that significantly influences the global research community.

Although rarely used, instruments such as the Cognitive Anxiety Test Questionnaire (CATQ) and the Math Anxiety Scale (Math-AS) still make significant contributions because they focus on the cognitive aspects of mathematics anxiety, such as the role of students' working

memory and numerical skills. Cognitive-based instruments are important because they directly correlate mathematics anxiety and information processing in elementary school children (Hopko et al., 2003; Karlimah et al., 2020). The Children's Math Anxiety Scale (CMAS-UK) and other variations of similar instruments were developed specifically for children with age sensitivity and educational context in mind. However, the low number of citations and usage of instruments such as the GMAQ, MAMAS, and MAMASE indicate that these instruments are still in development or have limited adoption in the international research community.

Theoretical Foundation (Q2: What is the main theoretical foundation of mathematics anxiety in primary education)

Mathematics anxiety involves psychological, cognitive, and social factors (Cohen & Rubinsten, 2021; Rada & Lucietto, 2022). Based on the data from our analysis in Table 3, Anxiety Theory is the most widely used theoretical basis with a contribution of 20% of the total articles, as supported by the research of Larkin & Jorgensen (2016), Lennon-Maslin et al. (2024), Lennon-Maslin & Quaiser-Pohl (2024) and Supriadi et al. (2024). Meanwhile, cognitive load theory, expectancy-value theory, and attentional control theory each make a 15% contribution. Other theories, such as the Theory of Achievement Emotions, Deficit Theory, Reciprocal Theory, Gender Role Theory, Emotion Regulation Theory, Self-Efficacy Theory, and Cognitive Interference Theory, contribute 5% each to the total articles.

Anxiety Theory dominates in research on mathematics anxiety in primary education. This theory explains that math anxiety appears as a negative emotional response to mathematical situations that are considered stressful or challenging (Beilock & Maloney, 2015; Prodromou & Frederiksen, 2018). Larkin & Jorgensen (2016) Emphasized that this feeling of anxiety can trigger avoidance of mathematics tasks and reduce students' learning motivation. This finding is in line with research by Lennon-Maslin et al. (2024), which shows that math anxiety in elementary school students is often related to previous negative experiences, both in the school environment and at home.

Table 3. The theoretical foundations of mathematics anxiety in elementary education

Theoretical Foundations	Total Article	Percentage	Reference
Anxiety Theory	4	20%	Larkin & Jorgensen, 2016; Lennon-Maslin et al., 2024; Lennon-Maslin & Quaiser-Pohl, 2024; Supriadi et al., 2024)
Cognitive Load Theory	3	15%	Caviola et al., 2017; Mavilidi et al., 2020; Nyroos et al., 2015
Expectancy-Value Theory	3	15%	Chen, 2019; Doz et al., 2023; Rodríguez et al., 2020
Attentional Control Theory	3	15%	Field et al., 2019; Hartwright et al., 2018; Shi et al., 2022
Theory Of Achievement Emotions	1	5%	Li et al., 2023
Deficit Theory	1	5%	Ching et al., 2020
Reciprocal Theory	1	5%	Szczygieł et al., 2024
Gender Role Theory	1	5%	Xie et al., 2024
Emotion Regulation Theory	1	5%	Petronzi et al., 2024
Teori Self-Efficacy	1	5%	Guntur & Purnomo, 2024
Cognitive Interference Theory	1	5%	Möhring et al., 2024

Cognitive Load Theory focuses on how cognitive load affects students' working memory capacity in completing mathematics tasks (Hery Murtianto et al., 2022; Paas & Ayres, 2014; Sweller, 2011). According to Caviola et al. (2017), math anxiety causes cognitive overload,

where anxious thoughts disrupt students' working memory capacity, thus inhibiting numerical processing and problem-solving. Mavilidi et al. (2020) Added that physical activity-based interventions can help reduce this cognitive load and increase students' focus on mathematics tasks.

Expectancy-value theory highlights the role of motivation in mathematics anxiety. Chen (2019), Doz et al. (2023), and Rodríguez et al. (2020) Explained that students who have low expectations of their mathematics abilities tend to experience higher anxiety. This theory states that low perceptions of positive values towards mathematics lead to decreased interest and self-confidence, ultimately triggering math anxiety. (Vásquez-Colina et al., 2014; Zakaria & Nordin, 2008). Further research shows that increasing students' self-confidence through positive learning approaches can significantly reduce these anxiety levels and promote better academic achievement in mathematics (Passolunghi et al., 2016; Villavicencio & Bernardo, 2016).

Attentional Control Theory explains that math anxiety affects students' attention control mechanisms. Field et al. (2019), Hartwright et al. (2018), and Shi et al. (2022) State that students with high levels of anxiety have difficulty focusing their attention on math tasks because their attention is distracted by negative thoughts or fear of failure. This suggests the importance of interventions designed to improve attentional control and reduce the negative impact of anxiety so that students can be more effective in learning and solving mathematics problems (González-Gómez et al., 2024).

Other theories, although less dominant, still play an important role in explaining specific aspects of math anxiety. For example, the Theory of Achievement Emotions focuses on the relationship between positive and negative emotions in academic achievement (Li et al., 2023), while the Self-Efficacy Theory emphasizes the importance of students' self-confidence in overcoming mathematics challenges (Guntur & Purnomo, 2024).

Gender Role Theory highlights the role of gender stereotypes in influencing mathematics anxiety, especially in female students, and dominates research on mathematics anxiety in primary education (Xie et al., 2024). This theory explains that anxiety, including math anxiety, arises as a negative emotional response to mathematical situations that are considered stressful or challenging. Larkin and Jorgensen (2016) emphasize that these feelings of anxiety can trigger avoidance of mathematics tasks and reduce students' learning motivation. This finding is in line with research (Lennon-Maslin et al., 2024), which shows that math anxiety in primary school students is often related to previous negative experiences, both in the school environment and at home

Causal Factors (Q3: What are the factors that cause mathematics anxiety in primary education?)

Mathematics anxiety in elementary education is a complex phenomenon that is influenced by various internal and external factors. Internal factors include students' cognitive and psychological aspects, while external factors relate to the learning environment, such as gender roles, curriculum, and regional conditions. The data analysis we present (Figure 5) maps the proportion of causes of mathematics anxiety, which are divided into several main categories: cognitive, gender, region, and curriculum.

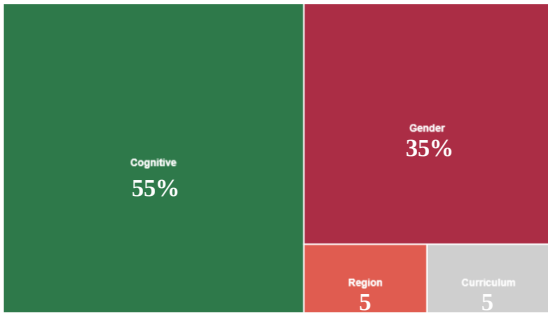

Figure 5. Factors causing mathematics anxiety

Cognitive factors are the leading cause of mathematics anxiety at the primary education level, with a contribution of 55%. This factor includes aspects of working memory, students'

negative perceptions of mathematics, and limited numerical abilities. According to Nur et al. (2018), students with low working memory capacity tend to have difficulty processing mathematical information, which then triggers anxiety. This is exacerbated when students do not have adequate strategies to overcome complex mathematics tasks. In addition, negative perceptions of self-ability in mathematics often affect motivation and increase student anxiety. (Supriadi et al., 2024; Vásquez-Colina et al., 2014).

Gender factors contribute 35%, indicating that gender differences play a significant role in the development of mathematics anxiety. Research by Xie et al. (2024) stated that gender stereotypes, where mathematics is often considered a male domain, can cause female students to experience higher anxiety. Hikmatul et al. (2021) Also emphasized that teacher attitudes can influence negative perceptions of female students towards mathematics.

The regional and curriculum factors, each with a contribution of 5%, reflect a smaller but still significant influence of the external environment. Regional factors refer to geographical disparities in providing educational resources, such as learning facilities, teacher training, and access to technology. Students in areas with limited resources often show higher levels of anxiety due to less-than-optimal teaching quality (Li et al., 2023; Szczygieł et al., 2024). Meanwhile, curriculum factors include teaching methods that are not according to students' needs. Curriculums that focus too much on results and exams can increase pressure on students, triggering anxiety (Chen, 2019; Petronzi et al., 2024).

Effective Interventions (Q4: What kind of interventions are carried out to reduce the level of mathematics anxiety in primary education?)

Interventions in addressing mathematics anxiety in primary education play a crucial role in ensuring that students can learn mathematics optimally without experiencing emotional and cognitive barriers. The right approach can help reduce students' anxiety and increase their confidence in facing mathematical tasks. Based on the analysis of our findings, effective interventions are classified into four main approaches, namely Pedagogical Approach, Psychological Approach, Teacher Support, and Technology Intervention, each with varying proportions (Figure 6).

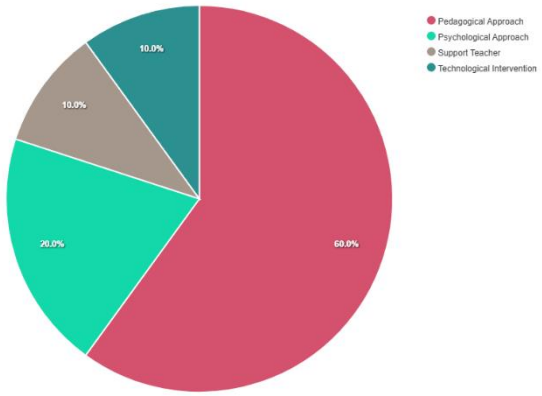

Figure 6. Interventions to reduce the level of mathematics anxiety

The pedagogical approach is the most dominant intervention, contributing 60%, followed by the Psychological Approach, which contributed 20%. Meanwhile, teacher support and technology intervention each contributed 10%. This proportion shows that the main focus of the intervention is on teaching methods, with significant support from psychology-based approaches.

The pedagogical approach, which dominates with 60%, focuses on improving teaching methods and designing a more inclusive and student-friendly curriculum. Constructivist and inquiry-based learning teaching methods can help students understand mathematical concepts better, reducing the perception that mathematics is a complex and scary subject (Nyroos et al., 2015; Shi et al., 2022). This approach involves active learning activities, mathematical manipulatives, and fun game-based learning to create a positive experience in learning mathematics (Kim & Albert, 2015; Yu et al., 2021).

Psychological approaches contribute 20%, focusing on interventions that address

students' emotional aspects. This approach includes relaxation techniques, stress management, and cognitive-behavioral-based therapy. Psychological approaches help students identify and overcome negative thoughts that trigger math anxiety (Pérez-Fuentes et al., 2020; Shi et al., 2022). In addition, mindfulness and deep breathing-based interventions are also effective in reducing students' anxiety levels and increasing learning focus (Mutlu, 2019; Rada & Lucietto, 2022).

Teacher support, which contributed 10%, emphasized the important role of teachers in creating a supportive and stress-free learning environment. Teachers who demonstrate a positive attitude toward mathematics and support student development can significantly reduce anxiety levels (Ober et al., 2021; Ober & Cheng, 2021). Teacher support includes providing positive feedback, patient teaching, and building student confidence through appropriate praise (Li et al., 2023).

Although only contributing 10%, technology interventions show great potential in helping students overcome mathematics anxiety. Technologies such as interactive learning applications, digital-based math games, and learning videos can help students understand the material more interestingly and easily. Chen (2019) emphasized that technology can reduce anxiety by providing a flexible and stress-free learning environment.

IV. Conclusion

Research on mathematics anxiety in primary education has grown significantly in recent years, reflecting increasing global attention. Key contributors include countries such as China and the UK, with prominent publications in journals like the Journal of Educational Computing Research, International Journal of Science and Mathematics Education, and International Journal of Environmental Research and Public Health. Keyword analysis highlight themes like math anxiety, self-efficacy, academic performance, and working memory, showcasing a multidisciplinary approach. The use of instruments like the Abbreviated Math Anxiety Scale (AMAS) underscores the importance of valid and reliable tools in assessing mathematics anxiety. Theoretically, this issue is explained through frameworks such as Anxiety Theory, Cognitive Load Theory, and Expectancy-Value Theory, which address emotional, cognitive, and motivational dimensions. Internal factors, including working memory limitations and negative perceptions, and external factors like gender stereotypes and curriculum pressures exacerbate anxiety. Effective interventions include activity-based learning, cooperative strategies, psychological support, and interactive technology, fostering inclusive pedagogy and reducing stress. This study affirms the complexity of mathematics anxiety. It highlights the need for collaborative efforts among researchers, educators, and policymakers to implement evidence-based interventions, improve learning experiences, and promote student success in mathematics.

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