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Math Anxiety and Instruction: Bridging the Gap through a Psychosociological Lens

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Abstract

Math anxiety is a pervasive phenomenon impacting learners across various educational levels, influencing cognitive functioning, emotional well-being, and long-term academic outcomes. This literature review synthesizes 58 sources to examine math anxiety through a psychosociological lens, integrating psychological, cognitive, and sociocultural perspectives. Findings highlight the multifaceted nature of math anxiety, including its impact on working memory, problem-solving, and academic achievement, as well as the role of family, peers, and classroom environments in shaping students' attitudes and experiences. Instructional coaching, leadership, and evidence-based pedagogical strategies emerge as critical supports for mitigating anxiety, promoting confidence, and fostering inclusive mathematics learning. Gaps in the literature include limited research on long-term intervention efficacy, the role of math coaching, and the interaction of sociocultural factors with individual differences. By bridging research and practice, this review provides guidance for educators and scholars to develop holistic, student-centered approaches that enhance mathematical competence, engagement, and resilience.

Keywords: Mathematics Anxiety, Psychosociology, Math Instruction, Anxiety, Math Education, Sociology, Educational Psychology, Cognition and Learning

Introduction

Math anxiety is a prevalent issue in classrooms of various age groups, marked by tension, fear, or helplessness when engaging with math tasks. It can negatively affect performance, confidence, and motivation across educational levels (Ashcraft & Krause, 2007; Dowker et al., 2016). Beyond individual outcomes, math anxiety also contributes to broader educational inequities, particularly for students with diverse learning needs (Ramirez et al., 2018).

This issue spans across age groups - from early learners who are developing important numeracy skills to postsecondary students facing more complex mathematics

courses and concepts in their learning (Ashcraft & Krause, 2007). Math anxiety impacts not only those who struggle academically but also high-achieving students whose anxiety can impair working memory and problem-solving skills and abilities (Ashcraft & Krause, 2007). Educators play a critical role in identifying signs of math anxiety and implementing strategies that foster inclusive, low-stress learning environments that are student-centered (Rogers, 1969).

This literature review synthesizes 58 sources, including seminal and recent studies, as well as some grey literature, to examine math anxiety from both psychological and sociological perspectives alike. The goal is to explore how math anxiety is shaped by internal and external factors, with particular attention to terminology, leadership, and psychosociological approaches relevant to educators and researchers as well. Furthermore, this literature review adopts a psychosociological approach to math anxiety, recognizing it as both an individual psychological experience and a socially influenced phenomenon. While the *APA Dictionary of Psychology* defines mathematics anxiety as "apprehensiveness and tension associated with the performance of arithmetic and other mathematical tasks" (American Psychological Association, 2018), this definition alone does not account for the broader societal and educational structures that contribute to the development of math anxiety needs. A psychosociological perspective integrates the emotional and cognitive challenges noted in psychological definitions (American Psychological Association, 2023; 2018a) with the recognition that math anxiety can be shaped by cultural norms, social expectations, and institutional pressures as well (American Psychological Association, 2018b). This intersectional lens allows for a deeper understanding of how learning difficulties, such as mathematics disorder or broader learning disorders, may be compounded by social dynamics in the classroom and beyond (American Psychological Association, 2018; 2023). Furthermore, clinical presentations like arithmophobia, while not formally classified in the DSM-5, exemplify how anxiety toward math can manifest in ways that negatively impact both academic and daily functioning for learners (Cleveland Clinic, 2022).

Research Questions

1) What gaps exist in the current literature on math anxiety that are most relevant to advancing both educational research and classroom practice?
2) How can identifying gaps in math anxiety research inform evidence-based strategies for educators to better support student learning and well-being?

Theoretical Framework

This literature review was guided by a psychosociological framework, which

integrates psychological understandings of math anxiety as an affective and cognitive response with sociological perspectives that situate anxiety within broader educational, cultural, and institutional systemic levels. This multidisciplinary lens supported analysis of both individual learner experiences and the systemic factors that may shape those learning experiences, including classroom environments, instructional practices, and educational policy contexts.

Methods

This study employed an integrative literature review design to examine math anxiety from both psychological and sociological perspectives. An integrative review approach was selected to allow for the inclusion of more diverse methodologies and resources (e.g., quantitative, qualitative, grey literature with a professional focus and theoretical work) and to generate a more comprehensive understanding of how math anxiety is conceptualized, experienced, and addressed across diverse educational contexts and situations. This design is appropriate for synthesizing both scholarly literature and grey literature in order to identify patterns, gaps, and intersections across these bodies of research.

The final collection of texts consisted of 58 sources, including seminal scholarly works, contemporary empirical studies, and selected grey resources as well to give a stronger picture of this field. These sources were selected to ensure a balance between foundational scholarship and more recent developments in the field of math anxiety. The dataset included work from psychology, education, and interdisciplinary fields to support the psychosociological lens guiding this scholarly review.

Data Analysis

Data analysis followed an inductive thematic analysis approach, supported by an initial categorization of the literature into three predetermined domains. Following full review and annotation of the selected sources, all 58 studies were organized into three primary categories based on relevance and conceptual focus: (1) terminology-related sources including definitional and diagnostic framing of math anxiety, primarily drawing from the American Psychological Association resources and clinical references from the Cleveland Clinic (n=6), (2) Instructional Coaching and Leadership in Mathematics (n = 7), and (3) Math Anxiety and Psychosociological Factors (n = 45).

This initial categorization functioned as a descriptive filtering process to organize the literature prior to thematic analysis. Once categorized, an annotated bibliography was developed for each source to identify key findings, conceptual contributions, and recurring ideas across the dataset. This annotated bibliography can be highly useful for researchers

and practitioners alike.

Following this process, the literature was subjected to iterative thematic analysis. Codes were generated from the annotated entries and refined through repeated comparison across sources within and between categories. These codes were then synthesized into four overarching themes that captured the primary dimensions of math anxiety across the literature:

1. Instructional Coaching and Leadership in Mathematics
2. Cognitive and Affective Research on Math Anxiety
3. Sociocultural and Environmental Impacts of Math Anxiety
4. Teaching, Learning, and Math Anxiety

These themes reflect both psychological and sociological dimensions of math anxiety and provide the analytical structure for interpreting gaps in the literature and implications for instructional practices.

Table 1: Key terminology (6 resources)

Author	Title	Year	Publisher/Journal
American Psychological Association	Mathematics anxiety	2018	APA Dictionary of Psychology
American Psychological Association	Learning disorder	2023	APA Dictionary of Psychology
American Psychological Association	Mathematics disorder	2023	APA Dictionary of Psychology
American Psychological Association	Sociology	2018	APA Dictionary of Psychology
American Psychological Association	Psychosocial	2018	APA Dictionary of Psychology
Cleveland Clinic	Arithmophobia (fear of numbers)	2022	Cleveland Clinic

Key Terminology (6)

American Psychological Association. (2018). Mathematics anxiety. *APA dictionary of psychology*. https://dictionary.apa.org/mathematics-anxiety. The APA Dictionary of Psychology defines mathematics anxiety as "apprehensiveness and tension

associated with the performance of arithmetic and other mathematical tasks." This concise definition underscores the emotional and cognitive barriers and challenges that individuals face when engaging with mathematical activities. This definition is particularly useful for academic and clinical contexts where a standardized understanding of the term is required.

American Psychological Association. (2023). *Learning disorder*. *APA dictionary of psychology*. https://dictionary.apa.org/learning-disorder. This entry defines "learning disorder" as a neurodevelopmental disorder characterized by difficulties in learning and academic skills, such as reading, writing, or math, which are significantly below expected achievement levels given the individual's age, intelligence, and education level. The definition highlights that the disorder can interfere with academic achievement or daily living activities requiring these skills. The APA Dictionary provides a concise and clinically grounded explanation useful for educators, psychologists, and researchers interested in understanding diagnostic criteria and the conceptual framework of learning disorders.

American Psychological Association. (2023). *Mathematics disorder*. *APA dictionary of psychology*. https://dictionary.apa.org/mathematics-disorder. This entry defines mathematics disorder as a specific learning disorder characterized by difficulties in understanding numbers, learning math facts, and performing accurate or fluent calculations, which significantly interfere with academic achievement or daily activities around numbers. The definition further clarifies that this disorder is not due to general intellectual disabilities or inadequate instruction but reflects a neurodevelopmental condition. This source provides a clear explanation of the clinical characteristics and diagnostic considerations related to mathematics disorder, making this valuable for educators, clinicians, and researchers focusing on math learning differences.

American Psychological Association. (2018). *Sociology*. *APA dictionary of psychology*. https://dictionary.apa.org/sociology. This dictionary entry defines *sociology* as the scientific study of human society, social relationships and institutions, emphasizing the patterns of social behaviour and the influence of social structures on individuals. Provided by the American Psychological Association, the definition bridges psychology and sociology by framing social behaviour as both an individual and collective phenomenon. This resource is useful for understanding how sociological perspectives inform psychological research, particularly in areas like social identity, group dynamics, and cultural influences on behaviour. It offers a concise, credible foundation for interdisciplinary work in the social sciences.

American Psychological Association. (2018). *Psychosocial*. *APA dictionary of psychology*. https://dictionary.apa.org/psychosocial. This entry defines *psychosocial* as an adjective describing the complex interactions among social, cultural, and environmental influences on mental processes and behaviour. The definition is concise yet comprehensive, highlighting the term's relevance across disciplines including psychology,

sociology, and education. It underscores that psychosocial factors are not isolated mental or social phenomena but emerge through their dynamic intersection. This resource is valuable for researchers and practitioners seeking a clear, authoritative understanding of how interpersonal and contextual factors interplay with psychological functioning.

Cleveland Clinic. (2022, March 22). *Arithmophobia (fear of numbers).* Cleveland Clinic. https://my.clevelandclinic.org/health/diseases/22545-arithmophobia-fear-of-numbers. This comprehensive health library article from the Cleveland Clinic defines arithmophobia, also referred to as numerophobia, as the fear of numbers - ranging from aversion to specific numbers that may or may not hold cultural significance (e.g., 13, 666) to an irrational fear of numbers more generally. While not a widely used term, it is important nonetheless as we study this important topic of math anxiety. This resource outlines the various potential symptoms, such as dizziness, sweating, and heart palpitations, and describes how the phobia can significantly disrupt personal and professional life - for example, hindering financial management or daily decision-making skills and capacities. The article discusses diagnostic criteria, noting that while not an official DSM-5 diagnosis, it shares attributes with specific phobias, such as recognition of irrational fear and avoidance behaviours. It also reviews evidence-based interventions including exposure therapy, cognitive behavioural therapy (CBT), hypnotherapy, and, where appropriate, anti-anxiety medications and offers lifestyle strategies for symptom management. This source is valuable for anyone researching the clinical presentation, impact, and treatment of numerical phobias in medical or psychological fields.

Table 2: Instructional coaching and leadership in mathematics (7 resources)

Author	Title	Year	Publisher/Journal	Type of Resource
Campbell, P. F.	The impact of elementary mathematics coaches on student achievement.	2011	The Elementary School Journal	Scholarly Research Article
Horne, D	School leadership's role in the disruption of math anxiety	2022	International Journal for Leadership in Learning	Scholarly Research Article
Joyce, B., & Showers, B.	Student achievement through staff development	2002	Association for Supervision and Curriculum Development	Research Based Professional Resource
Knight, J.	Instructional coaching: A partnership approach to improving instruction	2007	Corwin Press	Research Based Professional Resource
Mangin, M. M., & Stoelinga, S. R	Effective teacher leadership: Using research to inform and reform	2008	Teachers College Press	Research Based Professional Resource
Showers, B., & Joyce, B	The evolution of peer coaching	1996	Educational Leadership	Scholarly Research Article
Will, M	Are math coaches the answer to lagging achievement?	2020	Education Week	Professional Education News Article

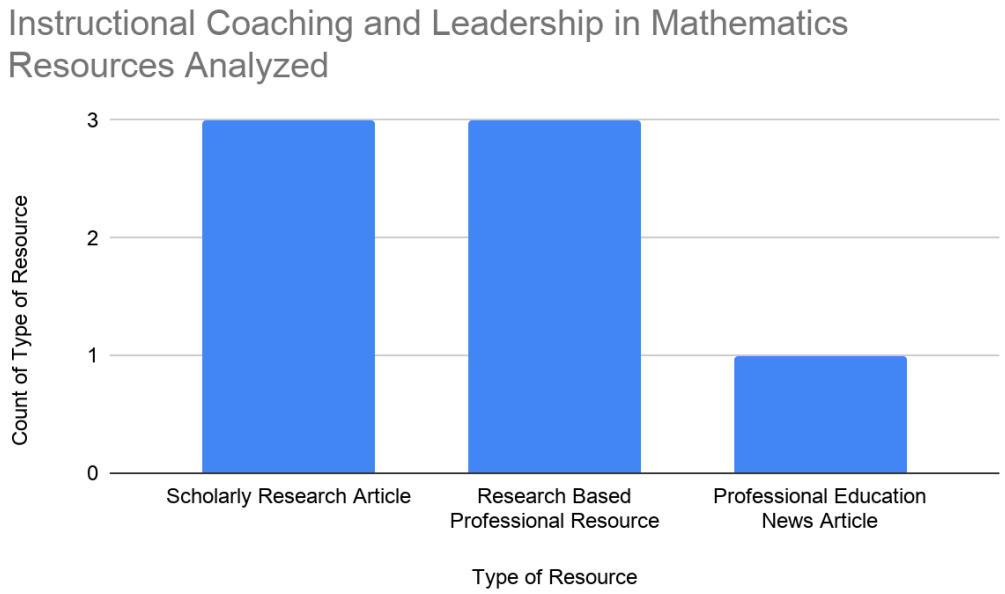

Figure 1: Instructional Coaching and Leadership in Mathematics Resources Analyzed

Instructional Coaching and Leadership in Mathematics (7)

Campbell, P. F. (2011). The impact of elementary mathematics coaches on student achievement. *The Elementary School Journal, 111*(3), 430–454. https://doi.org/10.1086/657654

This large-scale study examines the effect of elementary math coaches on student performance over three years. Results show that schools with full-time math coaches experienced statistically significant improvements in student achievement, particularly when coaches focused on content-rich support and ongoing collaboration through the coaching process. The study highlights the importance of sustained, embedded coaching in promoting instructional quality and learning outcomes in schools.

Horne, D. (2022). School leadership's role in the disruption of math anxiety. *International Journal for Leadership in Learning, 22*(1), 48–72. https://doi.org/10.29173/ijll4

This article examines how school leadership can effectively address and reduce math anxiety among both teachers and students. The author highlights that math anxiety is a widespread need that can negatively impacts student learning, engagement and achievement, as well as teachers' confidence and instructional practices. The researcher argues that school leaders play an important role in identifying math anxiety and fostering

a school culture that supports both teacher and student growth in mathematics. By combining instructional and transformational leadership approaches, leaders can create an environment aligned with learning organization principles to promote knowledge-sharing and improve math outcomes. This resource is potentially valuable for educators, administrators and researchers interested in leadership strategies to combat math anxiety and enhance math instructional practices at the school level.

Joyce, B., & Showers, B. (2002). *Student achievement through staff development* (3rd ed.). Association for Supervision and Curriculum Development. This text emphasizes that professional development that includes coaching and opportunities for practice leads to improved teacher effectiveness and student achievement. It provides empirical support for coaching as a vital component of sustained instructional improvement, including in math teaching and learning.

Knight, J. (2007). *Instructional coaching: A partnership approach to improving instruction*. Corwin Press.

Knight's influential book presents a comprehensive framework for instructional coaching based on partnership and trust between coach and educator in the classroom. The model has significantly impacted math coaching strategies and practices by emphasizing goal-setting, adult learning principles, and data-informed coaching conversations to improve instructional practices and strategies.

Mangin, M. M., & Stoelinga, S. R. (2008). *Effective teacher leadership: Using research to inform and reform*. Teachers College Press.

Mangin and Stoelinga explore how coaching functions as a method of teacher leadership, promoting instructional improvement through collaborative professional relationships. Their work highlights the connection between coaching and making systemic change, particularly relevant for math coaching initiatives which aim for a school-wide impact.

Showers, B., & Joyce, B. (1996). The evolution of peer coaching. *Educational Leadership, 53*(6), 12–16.

This foundational article traces the development of peer coaching models in education. It outlines how coaching can create collaborative learning environments among educators, which sets the stage for subject-specific coaching such as math coaching in particular. The article highlights the role of feedback and reflection in professional growth and development.

Will, M. (2020, May 5). Are math coaches the answer to lagging achievement? *Education Week.* https://www.edweek.org/teaching-learning/are-math-coaches-the-answer-to-lagging-achievement/2020/05

This practitioner-focused article highlights emerging evidence around math coaching and its potential impact on student achievement in math. It draws on expert commentary and recent studies to argue that effective coaching programs require sustained

time, trust, content knowledge, and classroom presence. While not a peer-reviewed study, it is useful for understanding how research is being interpreted and applied in school settings.

Instructional Coaching and Leadership in Mathematics

Instructional leadership and coaching practices in schools play a significant role in supporting educators to address math anxiety and improve instructional effectiveness at various age levels in schools. Research has consistently shown that coaching - when sustained, collaborative, and content-rich - can significantly enhance student learning outcomes in mathematics (Campbell, 2011). Campbell, in a large-scale, multi-year study, found that schools with full-time elementary math coaches experienced statistically significant improvements in student achievement (2011). The impact was most pronounced when coaches engaged in ongoing collaboration with teachers and focused on deep content knowledge (Campbell, 2011).

Leadership is also a critical factor in setting the conditions under which coaching and instructional support can thrive and improve practice (Horne, 2022). Horne highlights how school leaders who adopt both instructional and transformational leadership skills and strategies can create supportive cultures that disrupt the unhelpful cycle of math anxiety (2022). This involves recognizing the emotional and pedagogical components of math instruction and actively fostering teaching and learning environments grounded in trust, reflection, and shared learning goals (Horne, 2022).

The foundational work of Joyce and Showers (2002) further supports the idea that professional development efforts - including coaching - are essential for sustainable improvements in teaching and learning. Their earlier work (Showers & Joyce, 1996) traces the evolution of peer coaching, emphasizing the role of feedback, mutual support, and reflective practice as key components of teacher growth and development. Similarly, Mangin and Stoelinga (2008) position instructional coaching as a form of teacher leadership, demonstrating how collaborative professional relationships can influence system-wide change in instructional practices.

Knight's research reinforces the importance of a partnership-based coaching model grounded in trust and mutual respect to benefit the educator's practices (2007). His approach centers on adult learning principles and data-informed dialogue, enabling math educators to refine strategies in real time (Knight, 2007). These practices align with emerging reports in the practitioner literature, such as Will (2020), who notes that impactful coaching moves depend on sustained time, trust, and the coach's presence within the classroom. Though not a peer-reviewed publication, such sources illustrate how research-based practices are interpreted and applied within school systems today (Will, 2020). Together, these works affirm the value of instructional coaching and leadership as key

levers for addressing math anxiety and improving mathematics instruction across school communities.

Table 3: Math Anxiety and Psychosociological Factors (45)

Author	Title	Year	Publisher/Journal	Type of Resource
Ainscow, M., Booth, T., & Dyson, A	Improving schools, developing inclusion	2006	Routledge	Research Based Professional Text
Ashcraft, M. H	Math anxiety: Personal, educational, and cognitive consequences. Current Directions in Psychological Science	2002	Current Directions in Psychological Science	Scholarly Research Article
Ashcraft, M. H., & Krause, J. A	Working memory, math performance, and math anxiety	2007	Psychonomic Bulletin & Review	Scholarly Research Article
Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C	A meta-analysis of the relation between math anxiety and math achievement.	2021	Psychological Bulletin	Scholarly Research Article
Beilock, S. L., & Willingham, D. T	Ask the Cognitive Scientist: Math anxiety: Can teachers help students reduce it?	2014	American Educator	Professional Education News Article
Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C	Female teachers' math anxiety affects girls' math achievement	2010	Proceedings of the National Academy of Sciences	Scholarly Research Article
Boaler, J	Mathematical	2015	Jossey-	Research Based

	mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching		Bass	Professional Text
Butterworth, B., Varma, S., & Laurillard, D	Dyscalculia: From brain to education	2011	Science	Scholarly Research Article
Chang, H., & Beilock, S. L	The math anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research	2016	Current Opinion in Behavioral Sciences	Scholarly Research Article
Chen, M. Y. K., Jamaludin, A., & Tan, A. L	Behavioural predictors of math anxiety	2023	arXiv preprint	Preprint Research Article
Cohen, L. D., & Rubinsten, O	Mothers, intrinsic math motivation, arithmetic skills, and math anxiety in elementary school	2017	Frontiers in Psychology	Scholarly Research Article
Dowker, A., Sarkar, A., & Looi, C. Y	Mathematics anxiety: What have we learned in 60 years?	2016	Frontiers in Psychology	Scholarly Research Article
Duncan, A	The Importance of Emotionally Safe Learning Environments in	2021	Education Development Center	Research Based Professional Text

	Mathematical Engagement			
Dweck, C. S	Mindset: The new psychology of success	2006	Random House	Research Based Professional Text
Eccles, J. S	Gendered educational and occupational choices: Applying the Eccles et al. model of achievement-related choices	2011	International Journal of Behavioral Development	Scholarly Research Article
Ferguson, J	Overcoming innumeracy Part 4: How do we talk to leaders about mathematics?		Jigsaw Learning	Research Based Professional Text
Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L	The role of parents and teachers in the development of gender-related math attitudes	2012	Sex Roles	Scholarly Research Article
Hattie, J	Visible Learning: A synthesis of over 800 meta-analyses relating to achievement	2009	Routledge	Research Based Professional Text
Hembree, R	The nature, effects, and relief of mathematics anxiety. Journal for Research in Mathematics Education	1990	Journal for Research in Mathematics Education	Scholarly Research Article
Johnson, D	Math anxiety: Literature review with references	2003	Humboldt State University	Research Based Professional Text

Kim, J., Shin, Y. J., & Park, D	Peer network in math anxiety: A longitudinal social network approach	2023	Journal of Experimental Child Psychology	Scholarly Research Article
Kunwar, R	Mathematics phobia: Causes, symptoms, and ways to overcome	2020	International Journal of Creative Research Thoughts	Scholarly Research Article
Lawson, A	What to look for: Facilitator's guide	2015	Pearson Canada	Research Based Professional Text
Luttenberger, S., Wimmer, S., & Paechter, M	Spotlight on math anxiety	2018	Psychology Research and Behavior Management	Scholarly Research Article
Maloney, E. A., & Beilock, S. L	Math anxiety: Who has it, why it develops, and how to guard against it	2012	Trends in Cognitive Sciences	Scholarly Research Article
Marsh, E.J. & Dolan, P.O	Test-induced priming of false memories	2007	Psychonomic Bulletin & Review	Scholarly Research Article
Nelson, J. M., & Harwood, H	Learning disabilities and anxiety: A meta-analysis	2011	Journal of Learning Disabilities	Scholarly Research Article
Paulos, J. A	Innumeracy: Mathematical illiteracy and its consequences	2001	Hill and Wang	Research Based Professional Text
Rada, E., & Lucietto, A. M	Math Anxiety - A Literature Review on Confounding Factors	2022	Journal of Research in Science, Mathematics and Technology Education	Scholarly Research Article
Ramirez, G.,	Math anxiety,	2013	Journal of	Scholarly

Gunderson, E. A., Levine, S. C., & Beilock, S. L	working memory, and math achievement in early elementary school		Cognition and Development	Research Article
Ramirez, G., Shaw, S. T., & Maloney, E. A	Math Anxiety: Past Research, Promising Interventions, and a New Interpretation Framework	2018	Educational Psychologist	Scholarly Research Article
Reid, J & Reid, M	Dynamic Communities of Math Learners: Fostering Well-Being and Reducing Anxiety	2022	LD@school	Research Based Professional Text
Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Reiska, P	Mathematics anxiety among STEM and social sciences students: The roles of mathematics self-efficacy, and deep and surface approach to learning	2020	International Journal of STEM Education	Scholarly Research Article
Rucchin, G	Coping with math anxiety key to learning, says Western Education expert.	2020	Faculty of Education, Western University	Research Based Professional Text
Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N	To what extent and under which circumstances are growth mind-sets important to academic achievement? Two	2018	Psychological Science	Scholarly Research Article

	meta-analyses			
Small, M	Good Questions: Great Ways to Differentiate Mathematics Instruction	2010	Solution Tree Press	Research Based Professional Text
Stella, M	Network psychometrics and cognitive network science open new ways for detecting, understanding and tackling the complexity of math anxiety: A review	2018	arXiv	Preprint Research Article
Sutomo, W. A. B., & Juandi, D	Systematic literature review: Identification of students' mathematical anxiety in mathematics learning	2024	Union: Jurnal Ilmiah Pendidikan Matematika	Scholarly Research Article
Szczygieł, M	When does math anxiety in parents and teachers predict math anxiety and math achievement in elementary school children? The role of gender and grade year.	2020	Social Psychology of Education	Scholarly Research Article
Tobias, S	Overcoming math anxiety	1978	W. W. Norton & Company.	Research Based Professional Text
Vakharia, V	Math Therapy™: 5 Steps to Help	2024	Corwin	Research Based Professional Text

	Your Students Overcome Math Trauma and Build a Better Relationship With Math			
Young, C. B., Wu, S. S., & Menon, V	The neurodevelopmental basis of math anxiety	2012	Psychological Science	Scholarly Research Article
Zablan, C. D	Arithmophobia and its effect on academic performance	2020	Scribd	Unpublished Thesis
Zettle, R. D., & Raines, S. J	The relationship of trait and test anxiety with mathematics anxiety.	2000	College Student Journal	Scholarly Research Article
Zuo, H., & Wang, L	The influences of mindfulness on high-stakes mathematics test achievement of middle school students	2023	Frontiers in Psychology	Scholarly Research Article

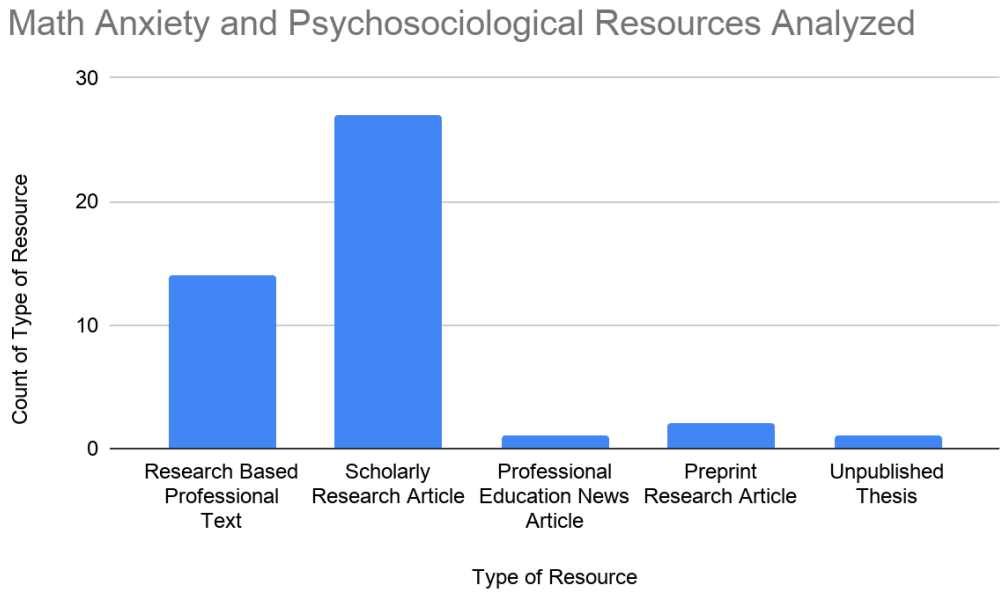

Figure 2: Math Anxiety and Psychosociological Resources Analyzed

Math Anxiety and Psychosociological Factors (45)

Ainscow, M., Booth, T., & Dyson, A. (2006). *Improving schools, developing inclusion*. Routledge. https://doi.org/10.4324/9780203967157

This text explores the relationship between school improvement and inclusive practices in education. The authors argue that inclusion should not be viewed as a separate initiative, but rather as a guiding principle embedded within efforts to enhance the quality and equity of education for all learners. Drawing on research and practical examples from schools in the UK and internationally, the book outlines strategies for addressing barriers to learning and participation, particularly for students with disabilities and those from marginalized backgrounds. It also introduces the "Index for Inclusion," a widely used tool for schools to self-evaluate their inclusive instructional practices. This source is quite relevant for educators, administrators, and policymakers aiming to foster more inclusive learning environments, as it offers both theoretical insights and actionable frameworks.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181–185. https://doi.org/10.1111/1467-8721.00196

Ashcraft's research presents a cognitive framework for understanding the impact of math anxiety on working memory and problem-solving skills. This concise yet influential research connects the dots between emotional responses and cognitive

performance, arguing that math anxiety impacts working memory resources necessary for computation and reasoning skills. The source is significant for translating complex psychological theory into implications for education and curriculum practices. This has shaped how researchers and practitioners understand the potential impacts of math anxiety on teaching and learning.

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*, 243–248. https://doi.org/10.3758/BF03194059

In this article, Ashcraft and Krause examine the cognitive underpinnings of math anxiety, focusing on the relationship between working memory and math performances. The researchers argue that math anxiety disrupts working memory capacity by acting as a secondary cognitive task, similar to the effects seen in dual-task interference. This disruption can impair math performance on tasks that go beyond simple recall and require active problem-solving. The article also explores developmental and educational contributors to math anxiety, emphasizing the long-term consequences such as avoidance of math-related courses, careers, and other opportunities. This research is essential for understanding how cognitive factors interact to impact learning outcomes and can inform classroom practices aimed at reducing anxiety levels and improving math achievement overall.

Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, *147*(2), 134–168. https://doi.org/10.1037/bul0000307

This meta-analysis synthesizes 747 effect sizes from studies conducted between 1992 and 2018 to update the understanding of the relationship between math anxiety and math achievement. The authors report a small-to-moderate negative correlation ($r = -.28$), consistent across most demographic and methodological subgroups. Significant moderators include grade level, type of math assessment, and specific math anxiety scales used. The findings show that math anxiety can begin early, can persist across lifespan, and can impact performance in diverse contexts around math.

Beilock, S. L., & Willingham, D. T. (2014). Ask the Cognitive Scientist: Math anxiety: Can teachers help students reduce it? *American Educator, 38*(2), 28–32. https://www.aft.org/ae/summer2014/beilock_willingham

This article explores the origins and impact of math anxiety, particularly in early education, and offers evidence-based strategies for educators to reduce its potential impacts. The authors discuss how math anxiety may impact working memory and can affects performance, especially under time pressure situations. They highlight social influences such as teacher and parental attitudes, and propose interventions like strengthening foundational skills, adjusting assessment methods, providing targeted teacher training, and using expressive writing exercises. The piece is grounded in cognitive

science and emphasizes a growth-oriented approach to help students develop confidence in math learning.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, 107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

This study investigates the impact of female elementary school teachers' math anxiety on the math achievement of their female students. Recognizing that over 90% of early elementary teachers in the U.S. are female, the researchers examined how teachers' math anxiety influences girls' beliefs about gender and math ability. The study assessed math anxiety in first- and second-grade female teachers and tracked the math achievement of their students over the school year. Results showed no initial effect of teacher anxiety on student performance, but by the end of the year, girls taught by more math-anxious teachers were more likely to endorse the stereotype that boys excel in math while girls excel in reading. This stereotype endorsement corresponded with significantly lower math achievement among these girls compared to boys and girls who rejected the stereotype. The findings highlight a subtle but important pathway through which teachers' emotional attitudes toward math can negatively affect girls' math outcomes, emphasizing the role of social and psychological factors in educational achievement.

Boaler, J. (2015). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey-Bass.

In this book, Jo Boaler argues that students' beliefs about their math abilities significantly shape their success. Drawing on research in education and cognitive science, she promotes a growth mindset approach to mathematics, emphasizing creativity, collaboration, and conceptual understanding over rote procedures. Boaler provides practical strategies for teachers to foster positive math identities, reduce anxiety, and shift classroom culture to one that encourages risk-taking and resilience. The book is particularly valuable for educators seeking to make math more inclusive and engaging for all learners.

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. *Science*, *332*(6033), 1049–1053. https://doi.org/10.1126/science.1201536

This article provides an overview of dyscalculia, a specific learning difficulty that can affect an individual's ability to understand and work with numbers. The researchers explore the neurobiological foundations of dyscalculia and its implications for potential classroom practices. They argue for early diagnosis and the use of targeted, evidence-based interventions to support mathematical development in students with dyscalculia. By connecting neuroscience research with educational strategies, the article bridges theory and practice, making it a valuable resource for both researchers and practitioners interested in supporting students with math-related learning difficulties.

Chang, H., & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and

psychophysiological research. *Current Opinion in Behavioral Sciences, 10*, 33–38. https://doi.org/10.1016/j.cobeha.2016.04.011

This research reviews the global prevalence of math anxiety and its association with poor math performance, exploring the underlying individual and environmental factors contributing to this need. It highlights cognitive, affective, physiological, and motivational mechanisms at the individual level, alongside social and contextual influences that can exacerbate math anxiety's impact on teaching and learning. The researchers summarize recent interventions aimed at reducing math anxiety and its negative effects on performance, emphasizing the importance of addressing both the individual's experience and their surrounding environmental factors. This study provides a comprehensive overview of current research and suggests that effective future interventions should take a holistic approach, targeting not only individuals with significant math anxiety but also key social influences to improve math outcomes for students.

Chen, M. Y. K., Jamaludin, A., & Tan, A. L. (2023). Behavioural predictors of math anxiety. *arXiv preprint*. https://arxiv.org/abs/2301.13639

This study examined behavioural predictors of math anxiety in elementary-aged students identified as low-progressing in math within an educational intervention programs. Ten types of behaviours, including counting aloud, were analyzed, and multiple linear regression revealed three specific behaviours significantly associated with higher math anxiety. The findings offer insights for early identification and intervention, while also discussing the study's limitations as well.

Cohen, L. D., & Rubinsten, O. (2017). Mothers, intrinsic math motivation, arithmetic skills, and math anxiety in elementary school. *Frontiers in Psychology, 8*, Article 1939. https://doi.org/10.3389/fpsyg.2017.01939

This study explores how environmental, cognitive, and personal factors simultaneously influence math anxiety in children, with a focus on maternal behaviours as key influences. Using both explicit and implicit measures of anxiety, researchers found that unconscious expressions of math anxiety in children were significantly shaped by their mothers' behaviours and anxiety levels - suggesting intergenerational transmission. This research highlights the socialization processes within families that contribute to math anxiety, reinforcing the importance of considering parental influence in the sociological study of educational outcomes in mathematics.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology, 7*, Article 508. https://doi.org/10.3389/fpsyg.2016.00508

This comprehensive review traces decades of research on math anxiety, covering its definition, measurement methods (including both questionnaires and physiological assessments), and its distinctiveness from general/test anxiety. The researchers examine the well-established negative correlation between anxiety and math performance -

particularly in tasks that demand working memory - and explore moderating factors such as genetics, age, gender, and cultural context. The review also examines neuroscientific findings linking math anxiety to activation in emotion-related brain regions and outlines emerging interventions. The article concludes by identifying gaps in this important field, including insufficient research on the interplay between social, neural, and developmental influences, as well as the need for long-term longitudinal and interdisciplinary studies.

Duncan, A. (2021). The Importance of Emotionally Safe Learning Environments in Mathematical Engagement. *Math for All*. https://mathforall.edc.org/supportive-learning-environments-in-mathematical-engagement

In this practitioner-focused article, Duncan explores the critical role of emotionally supportive learning environments in fostering engagement and achievement in mathematics spaces. Drawing on research by Berlin and Cohen, who analyzed over 400 elementary math lessons, Duncan emphasizes that emotionally safe, orderly, and engaging classrooms lead to deeper cognitive engagement with math content, especially in relation to Common Core-aligned practices such as productive struggle and mathematical reasoning. The article identifies four types of classroom profiles (Turbulent, Inconsistent, Orderly, Supportive), demonstrating that only classrooms with both structure and emotional support consistently showed high levels of student engagement in mathematics. Key strategies include fostering autonomy, active listening, positive student–teacher relationships, and constructive responses to misunderstanding. This resource underscores the importance of integrating social-emotional learning (SEL) with math instruction and is valuable for educators seeking to create inclusive, emotionally nurturing, and high-achieving math education environments.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

This book explores the profound impact of personal beliefs - both conscious and unconscious - on motivation, behaviour, and success. Through research findings, real-life stories, and practical examples, the book reveals how mindset affects performance across various domains, including science, arts, sports, and business. It also offers actionable strategies to identify and change limiting mindsets, enabling individuals to unlock their full potential. This resource is valuable for educators, psychologists, and anyone interested in personal development and the psychological factors underlying achievement.

Eccles, J. S. (2011). Gendered educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *International Journal of Behavioral Development, 35*(3), 195–201. https://doi.org/10.1177/0165025411398185

This article presents a theoretical model that examines how social, cultural, and psychological factors influence achievement-related decisions, particularly in relation to gendered educational and occupational choices. The author contends that both between-gender and within-gender differences stem from variations in individuals' expectations for success and the subjective value they assign to tasks. In the context of math and physical

science careers, women are underrepresented due to lower confidence in their abilities and less perceived value in these fields compared to others. The article emphasizes the impact of gendered socialization practices - from family, school, and peers - in shaping self-perceptions in this area.

Ferguson, J. (2020). Overcoming innumeracy Part 4: How do we talk to leaders about mathematics? *Jigsaw Learning*. https://www.jigsawlearning.ca/additional-services/blogs/overcoming-innumeracy-part-4-how-do-we-talk-leaders-about-ma

In this blog post, Ferguson explores practical strategies for initiating and sustaining productive conversations with school and system leaders about mathematics instruction. As the 4th part of the *Overcoming Innumeracy* series, the post encourages educators to invite leaders into the classrooms, co-analyze student data, and co-plan numeracy-focused professional learning opportunities. The resource is highly practical and supports educators in bridging the gap between classroom practices and leadership engagement, contributing to a more numerate and supportive learning environment.

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles, 66*(3-4), 153–166. https://doi.org/10.1007/s11199-011-9996-2

This article reviews research on gender differences in math attitudes, emphasizing that girls often report more negative attitudes - such as anxiety, gender stereotypes, and low self-concept - compared to boys. These attitudes significantly affect math achievement and engagement in STEM pathways. The researchers highlight how gender-biased expectations from parents and teachers influence children's math attitudes and performance. They propose three new research directions: (1) examining how adults' math anxieties and beliefs about fixed abilities shape children's attitudes; (2) applying a developmental lens to study early math attitudes alongside gender identity formation; and (3) identifying specific adult behaviours that transmit math-related gender biases. The researchers advocate for interventions that begin early and target both home and school environments to foster equitable opportunities in math spaces. This work is particularly valuable for educators, researchers, and policymakers focused on gender equity in STEM education.

Hattie, J. (2009). *Visible Learning: A synthesis of over 800 meta-analyses relating to achievement*. Routledge.

John Hattie's *Visible Learning* is a seminal work in educational research that synthesizes over 800 meta-analyses encompassing millions of students worldwide to identify the factors with the greatest impact on student learning and achievement. By calculating effect sizes for various influences - ranging from teaching strategies, student behaviours, to school-level factors - Hattie provides a comprehensive evidence-based hierarchy of what works best in education. His research challenges many common assumptions, emphasizing the critical role of teacher clarity, feedback, formative

assessment, and student self-efficacy. The book advocates for the notion of "visible learning," where both educators and students alike become active, reflective participants in the teaching and learning processes. This resource is essential for understanding evidence-based instructional practices in education and guiding decisions to maximize learning impact and efficacy to best support students and educators.

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

Hembree's meta-analysis synthesizes decades of scholarly research on math anxiety, providing a comprehensive overview of its nature, effects, and possible interventions. The analysis includes data from over 150 studies, categorizing the relationship between math anxiety, performance, and instructional practices. This work is pivotal in demonstrating the consistency of negative correlations between math anxiety and student achievement across multiple student populations. It also evaluates the effectiveness of various intervention strategies, making it a critical reference point for researchers and educators alike.

Johnson, D. (2003). *Math anxiety: Literature review with references.* Humboldt State University. https://lincs.ed.gov/professional-development/resource-collections/profile-193

This literature review by a mathematics professor examines math anxiety primarily in adults, addressing its definitions, prevalence, causes, effects, and treatments. It draws on research up to 2003 and includes both self-help and instructional interventions. The review also points to additional related resources available on the author's website.

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

This study examines how peer relationships influence math anxiety in children over the course of an academic semester. Using longitudinal peer network analysis, the researchers found that while students did not choose friends based on similar levels of math anxiety, their anxiety levels became more aligned with those of their peers over time. The findings suggest that peer influence contributes to the development of math anxiety and may have long-term implications for students' academic performance and career choices.

Kunwar, R. (2020). Mathematics phobia: Causes, symptoms, and ways to overcome. *International Journal of Creative Research Thoughts*. https://www.researchgate.net/publication/343655607_MATHEMATICS_PHOBIA_CAUSES_SYMPTOMS_AND_WAYS_TO_OVERCOME

This article explores the concept of mathematics phobia, specifically using the term "arithmophobia" to describe the fear of numbers. The researcher discusses the psychological and educational impacts of arithmophobia on students, highlighting its causes such as negative attitudes, poor teaching methods, and curriculum challenges. The

paper also outlines symptoms of math anxiety and offers practical strategies and interventions for educators and learners to overcome this need. This source provides a comprehensive overview useful for understanding the origins and effects of arithmophobia in educational contexts.

Lawson, A. (2019). *What to look for: Facilitator's guide*. Pearson Canada. This guide supports educators in using Lawson's developmental continua to observe and understand students' mathematical thinking. It provides video case studies, reflective prompts, and activities structured to help teachers inclusively address learners' needs. By focusing on purposeful, strategies-based games and classroom discussions and activities, it empowers teachers to scaffold instruction tailored to each student's current developmental phase - promoting inclusive practices and helping to potentially reduce math anxiety.

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

This peer-reviewed article explores math anxiety as a global phenomenon affecting individuals across all age groups, emphasizing its classification as a specific form of performance-related anxiety. The researchers present math anxiety as the result of a dynamic interaction of multiple variables, including environmental factors (e.g., parental and teacher attitudes), sociocultural stereotypes (particularly gender-based), and individual characteristics (e.g., self-efficacy and motivation). The paper examines both the short- and long-term effects of math anxiety on learning, academic performance, and career decision-making. Diagnostic tools and intervention practices are discussed, with an emphasis on early identification and tailored support across educational and familial contexts. The authors call for further research into personalized and systemic approaches to reduce math anxiety. This article serves as a comprehensive resource for educators, researchers, and policymakers seeking to understand and mitigate the impact of math anxiety.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences, 16*(8), 404–406. https://doi.org/10.1016/j.tics.2012.06.008

This article introduces math anxiety as a common emotional response to numerical information and highlights its impact on both academic performance and daily functioning. Recent research has begun to uncover the early origins and contributing factors of math anxiety, offering new perspectives on how math anxiety can develop and how it can be effectively addressed. The piece emphasizes the importance of identifying risk factors early and exploring evidence-based strategies for remediation.

Marsh, E.J. & Dolan, P.O. Test-induced priming of false memories. *Psychonomic Bulletin & Review 14*, 479–483 (2007). https://doi.org/10.3758/BF03194093

This study examines how prior testing of related words influences the formation

of false memories in using the Deese/Roediger-McDermott (DRM) paradigm. Researchers found that when participants had unlimited time to respond, earlier testing of related items made them recognize false memories faster but did not increase the number of false recognitions. However, a under time pressure, participants showed a higher rate of false memories, suggesting that speeded responses may prevent effective memory monitoring. The findings support the idea that recalling accurate memories can contribute to memory distortions through activation of related, non-presented concepts.

Nelson, J. M., & Harwood, H. (2011). Learning disabilities and anxiety: A meta-analysis. *Journal of Learning Disabilities, 44*(1), 3–17. https://doi.org/10.1177/0022219409359939

Nelson and Harwood (2011) conducted a meta-analysis of 58 studies comparing anxiety levels in school-aged students with learning disabilities (LD) to those without LD. The analysis revealed that students with LD exhibit significantly higher levels of anxiety, with a medium overall effect size (d = .61). Notably, results varied depending on the informant type (e.g., self, parent, teacher), which emerged as a significant moderator, and the source of LD identification also showed near-significant effects. The article highlights the importance of considering multiple perspectives in assessment and evaluation practices and tailoring interventions to address the potential elevated anxiety levels in students with LD. This research is valuable for educators, psychologists, and support staff working to create inclusive and emotionally supportive learning environments.

Paulos, J. A. (2001). *Innumeracy: Mathematical illiteracy and its consequences* (2nd ed.). Hill and Wang.

In this widely cited book, Paulos examines how a lack of basic mathematical understanding - what he terms "innumeracy" - impacts decision-making, media literacy, and public policy. Using accessible language and real-world examples, he highlights how statistical and probabilistic misunderstandings and misconceptions can lead to poor judgments in health, finance, and education practices. Though not a scholarly text, it is a key resource for educators and advocates aiming to improve numeracy and critical thinking in students and the broader population. It raises awareness of the importance of numeracy as a life skill and offers a cultural critique of how math is perceived and taught.

Rada, E., & Lucietto, A. M. (2022). Math Anxiety - A Literature Review on Confounding Factors. *Journal of Research in Science, Mathematics and Technology Education, 5*(2), 117-129. https://doi.org/10.31756/jrsmte.12040

This paper reviews literature on math anxiety, exploring its origins from innate predispositions, past math performance, and environmental influences including education systems, family, and societal stereotypes. It examines how high-stakes testing and negative mindsets exacerbate anxiety, impacting working memory and math performance. The paper concludes by proposing various strategies to help decrease levels of math anxiety and calls for future data-driven research on social stereotypes, support systems, and long-

term educational and career effects.

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187–202. https://doi.org/10.1080/15248372.2012.664593

This study investigates the relationship between math anxiety and achievement in first- and second-grade students, emphasizing the role of working memory (WM). The researchers found that math anxiety negatively affected performance only in children with higher WM, suggesting that these students may rely on cognitively demanding strategies that are more easily disrupted by math anxiety. The findings highlight the importance of early identification and intervention, especially for high-potential students who may otherwise disengage from mathematics subjects.

Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math Anxiety: Past Research, Promising Interventions, and a New Interpretation Framework. *Educational Psychologist*, *53*(3), 145–164. https://doi.org/10.1080/00461520.2018.1447384

Ramirez, Maloney, and Beilock (2018) present a comprehensive review of existing research on math anxiety, highlighting its negative association with math achievement and identifying key individual and contextual factors that contribute to its development. The researchers examine characteristics that may make students more vulnerable to math anxiety issues, such as prior academic experiences and self-perceptions of competence in math. Further, they introduce the "Interpretation Account", a new theoretical framework that emphasizes the role of appraisal processes - how students interpret their emotional responses - in the onset and management of math anxiety. The scholarly article also evaluates evidence-based interventions and provides guidance for educators to support students in overcoming math-related stress. Finally, the article identifies research gaps in the literature and calls for future researchers to refine theoretical models and improve classroom instructional practices.

Reid, J & Reid, M. (2022). *Dynamic Communities of Math Learners: Fostering Well-Being and Reducing Anxiety*. LD@school. https://www.ldatschool.ca/dynamic-communities-math-anxiety

This practitioner-focused publication provides a comprehensive overview of math anxiety, specifically for students with learning disabilities (LDs). This article offers actionable strategies and practices for educators to support students in inclusive classrooms. Reid highlights how math identity is socially constructed and influenced by a student's environment, teacher beliefs, and systemic inequities such as gender and socio-economic status. The article details how math anxiety can emerge early in childhood and potentially escalate without intervention, manifesting in both physical and behavioural symptoms. Reid outlines evidence-based strategies for reducing math anxiety, including reducing working memory load, using focused breathing, encouraging productive struggle,

and fostering growth mindsets. The authors emphasize the role of teachers in building positive math identities and cultivating dynamic, collaborative math learning environments.

Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Reiska, P. (2020). Mathematics anxiety among STEM and social sciences students: The roles of mathematics self-efficacy, and deep and surface approach to learning. *International Journal of STEM Education, 7*(1), Article 46. https://doi.org/10.1186/s40594-020-00246-z

This cross-sectional study explores the relationships between math anxiety, math self-efficacy, and learning approaches among STEM and social sciences students alike. The results show a strong negative correlation between math anxiety and self-efficacy, with lower self-efficacy and female gender predicting higher anxiety in STEM students. While surface learning approaches were associated with anxiety in STEM fields, these effects were not significant in multivariate models when self-efficacy was accounted for. The study emphasizes the central role of self-efficacy in math anxiety and suggests the need for future research to clarify the direction of this relationship.

Rucchin, G. (2020, April 15). *Coping with math anxiety key to learning, says Western Education expert*. Faculty of Education, Western University. https://www.edu.uwo.ca/news-events/2020/math-anxiety.html

In this article, Professor Daniel Ansari, a leading expert in developmental cognitive neuroscience, discusses the prevalence and impact of math anxiety among students. He cites a study indicating that 60% of Grade 8 students worry about math difficulties, and 30% feel tense during math homework. Ansari explains that math anxiety occupies working memory, reducing cognitive resources available for problem-solving. He emphasizes that math anxiety is not merely an emotional issue but also has cognitive consequences. The article also highlights the role of educators and parents in influencing students' math anxiety and further highlights the importance of addressing these anxieties to improve math learning outcomes.

Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science, 29*(4), 549-571. https://doi.org/10.1177/0956797617739704

This meta-analysis questions the strength and consistency of growth mindset effects on academic achievement. While the concept is promising, the study finds only modest effects overall and suggests that growth mindset interventions are less effective than initially reported, especially when implemented in real-world educational settings.

Small, M. (2009). *Good Questions: Great Ways to Differentiate Mathematics Instruction*. Solution Tree Press.

In this influential book, Marian Small provides educators with practical instructional strategies to differentiate mathematics instruction through the use of

purposeful and meaningful questioning. By emphasizing constructivist principles, Small advocates for engaging students in deeper mathematical thinking by posing varied and open-ended questions tailored to diverse learning needs in math. This resource offers concrete examples and classroom-tested techniques that help teachers stimulate critical thinking, promote problem-solving skills and strategies, and foster student ownership of their learning.

Stella, M. (2021). Network psychometrics and cognitive network science open new ways for detecting, understanding and tackling the complexity of math anxiety: A review. *arXiv*. https://arxiv.org/abs/2108.13800

This review conceptualizes math anxiety as a complex clinical condition impacting approximately 20% of students globally, impairing well-being, cognitive processing, and career prospects beyond what academic performance alone reveals. This article highlights the social transmission and subconscious impact of math anxiety and advocates for advanced network psychometrics and cognitive network science methods to detect, understand, and intervene on this multifaceted problem by mapping its interconnected emotional and cognitive factors.

Sutomo, W. A. B., & Juandi, D. (2024). Systematic literature review: Identification of students' mathematical anxiety in mathematics learning. *Union: Jurnal Ilmiah Pendidikan Matematika, 12*(1), 35–47. https://doi.org/10.30738/union.v12i1.16370

This systematic literature review analyzes 98 articles published between 2014 and 2022 on math anxiety across all education levels. Findings show a focus of the research on both soft and hard mathematical skills, with most studies centered on junior high students. Quantitative methods are predominantly used, highlighting trends and gaps in the current math anxiety scholarly literature.

Szczygieł, M. (2020). When does math anxiety in parents and teachers predict math anxiety and math achievement in elementary school children? The role of gender and grade year. *Social Psychology of Education*, *23*(4), 1023–1054. https://doi.org/10.1007/s11218-020-09570-2

This study examines the relationship between the math anxiety of adults - fathers, mothers, and teachers - and its impact on the math anxiety and achievement of first- to third-grade children. Findings of this article show that fathers' anxiety is linked to increased math anxiety in younger children and third-grade girls, while mothers' and teachers' anxiety predicts lower math achievement in 3rd-grade students. The study highlights the nuanced influence of adult figures on early learners, suggesting that while adults' anxiety may not directly shape children's math anxiety, it can negatively affect achievement outcomes, particularly in later primary grades.

Tobias, S. (1978). *Overcoming math anxiety.* W. W. Norton & Company.

Tobias's book was among the first to address math anxiety from a sociocultural and educational perspective. Aimed at a broad audience, this text highlights the

psychological and systemic factors contributing to math avoidance, specifically among women. Tobias integrates practical strategies with personal narratives and policy critique, effectively bringing attention to how societal expectations and instructional methods can potentially contribute to math-related fear. It remains a go-to resource for educators and students alike.

Vakharia, V. (2024). *Math Therapy™: 5 Steps to Help Your Students Overcome Math Trauma and Build a Better Relationship With Math*. Corwin.

In *Math Therapy™*, Vanessa Vakharia, known as "The Lady Gaga of Math," offers a transformative approach to addressing math anxiety in students. Drawing from her personal experiences and professional expertise, Vakharia introduces a 5-step framework - Mythbust, Moderate, Motivate, Makeover, and Measure - to help educators dismantle harmful math myths, moderate trauma responses, motivate students, revamp math identities, and measure progress. The book is grounded in research from math education and neuropsychology, providing practical strategies and tools for teachers to implement in the classroom. Vakharia's engaging writing style, complemented by humorous anecdotes, makes this resource both informative and accessible as well.

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science, 23*(5), 492–501. https://doi.org/10.1177/0956797611429134

This neuroimaging study explores the brain mechanisms underlying math anxiety in children aged 7 to 9. The researchers found that math anxiety is linked to increased activation in the right amygdala - an area associated with negative emotion - and reduced activation in brain regions critical for mathematical reasoning. These neural patterns were distinct from those associated with general anxiety or cognitive ability. The study is one of the first to identify biological correlates of math anxiety, offering promising potential insights for early detection and intervention in math anxiety and student learning.

Zablan, C. D. (2020). *Arithmophobia and its effect on academic performance* [Unpublishedthesis].Scribd.https://www.scribd.com/document/400460100/arithmophobia-and-its-effect-on-academic-performance

This study investigates the prevalence and impact of arithmophobia among Grade 12 STEM students, focusing on how this anxiety of mathematics influences academic achievement in subjects like chemistry and physics that require significant math skills. Zablan analyzes the causes of arithmophobia, its manifestation in student attitudes and performances, and emphasizes the need for targeted educational interventions to support these needs. The research contributes valuable data on the relationship between math-related anxiety and academic outcomes in science and technology education, making it relevant for educators seeking to support STEM learners.

Zettle, R. D., & Raines, S. J. (2000). The relationship of trait and test anxiety with mathematics anxiety. *College Student Journal, 34*(2), 246–258.

This study examines the relationship between math anxiety and more general forms of anxiety, such as trait anxiety and test anxiety. The researchers find that while math anxiety shares overlap with general anxiety constructs, it also presents as a distinct phenomenon with unique triggers and implications as well. Their findings support the need for targeted interventions that go beyond general anxiety treatment. This research is important for educators and mental health professionals looking to tailor supports specifically for math-anxious learners.

Zuo, H., & Wang, L. (2023). The influences of mindfulness on high-stakes mathematics test achievement of middle school students. *Frontiers in Psychology, 14*, Article 1061027. https://doi.org/10.3389/fpsyg.2023.1061027

This study demonstrates that mindfulness training significantly reduces math anxiety and improves performance. Students who practiced brief mindfulness strategies, such as breathing and focused attention, showed both emotional and academic benefits.

Cognitive and Affective Research on Math Anxiety

Math anxiety has been extensively documented as a phenomenon that can impair cognitive functioning, particularly working memory, which is essential for problem-solving and mathematical reasoning. Ashcraft (2002) highlights that anxiety reactions to academic and real-world math tasks consume cognitive resources, reducing students' ability to perform to the best of their abilities when anxious. Ashcraft and Krause (2007) further explain that math anxiety acts as a secondary cognitive task, potentially interfering with working memory and complex mathematical computational skills. Studies in neuroimaging support this cognitive perspective as well, showing that math anxiety increases activation of the amygdala - which is associated with negative emotions - while also decreasing engagement of brain regions critical for numerical reasoning and math skills (Young, Wu, & Menon, 2012). This scholarly evidence indicates that anxiety is not merely an emotional response but it has some tangible effects on cognitive processing, underscoring the importance of early identification and intervention in this important area (Ramirez, Gunderson, Levine, & Beilock, 2013; Maloney & Beilock, 2012).

Going beyond these cognitive impacts, math anxiety is also linked to broader educational and behavioral outcomes in schools (Hembree, 1990; Barroso, Ganley, McGraw, Geer, Hart, & Daucourt, 2021; Nelson & Harwood, 2011). Hembree's (1990) meta-analysis and Barroso et al.'s (2021) meta-analytic review confirm a consistent negative relationship between math anxiety and academic achievement across ages, demographics, and assessment types more generally. Students with learning disabilities are particularly vulnerable to this phenomenon, as they can exhibit higher anxiety and lower outcomes than non-anxious peers (Nelson & Harwood, 2011). Behavioral predictors, such as repetitive counting aloud or avoidance strategies, can also correlate to elevated math

anxiety in students (Chen, Jamaludin, & Tan, 2023), suggesting that observable classroom behaviors can potentially signal the presence of anxiety. Additionally, high-stakes testing and other negative experiences with mathematics exacerbate this significant and pervasive problem, contributing to long(er)-term avoidance of math-related courses and career opportunities (Rada & Lucietto, 2022; Zablan, 2020). Collectively, these findings demonstrate that math anxiety is both a cognitive and behavioral phenomenon with potentially lasting implications for educational and vocational trajectories (Barroso et al., 2021; Nelson & Harwood, 2011; Rada & Lucietto, 2022; Zablan, 2020).

Interventions that aim to mitigate math anxiety have ranged from psychological strategies to classroom practices and neurocognitive approaches alike (Ashcraft & Krause, 2007; Ramirez, Shaw, & Maloney, 2018; Young, Wu, & Menon, 2012; Zuo & Wang, 2023). Mindfulness techniques, for instance, have been shown to have positive results in reduce anxiety and improve math performance in middle school students (Zuo & Wang, 2023), while growth mindset and positive appraisal frameworks provide strategies to reframe students' perceptions of ability in mathematics and perceptions of needs as well (Ramirez, Shaw, & Maloney, 2018; Sisk et al., 2018). Cognitive and educational researchers also advocate for curriculum design that accommodates individual differences and scaffolds learning for students with dyscalculia or other learning difficulties as being very important also (Butterworth, Varma, & Laurillard, 2011). Foundational works by Tobias (1978) and Johnson (2003) emphasize the role of both educational practices and broader sociocultural factors, highlighting that targeted educational and psychotherapeutic interventions must integrate cognitive, emotional, and environmental components to be truly helpful and effective. Emerging models, such as the Interpretation Account (Ramirez et al., 2018) and network-based analyses of math anxiety (Stella, 2021), point toward increasingly nuanced understandings of the correlation and interplay between cognition, emotion, and context in shaping math performance and well-being.

Sociocultural and Environmental Impacts of Math Anxiety

Research further indicates that sociocultural factors, including family situations, peers, and teachers, play a significant role in the development and persistence of math anxiety in children (Beilock, Gunderson, Ramirez, & Levine, 2010; Cohen & Rubinsten, 2017; Kim, Shin, & Park, 2023; Szczygieł, 2020). Studies have shown that parents' attitudes toward mathematics, particularly maternal and paternal math anxiety, can shape children's emotional responses and performance in math (Cohen & Rubinsten, 2017; Szczygieł, 2020). Children often internalize both explicit and implicit messaging from adults about the value of math and their perceived abilities and skills, with female identifying students being especially susceptible to adopting gendered beliefs about math competence (Beilock, Gunderson, Ramirez, & Levine, 2010; Eccles, 2011). This shows a

significant need that educators should better support female identifying students in these subject areas. Peer groups and networks also contribute to the socialization of math anxiety, as children's higher anxiety levels tend to align with those of their classmates over time, indicating the powerful influence of social context on the individual learning experiences of various students (Kim, Shin, & Park, 2023).

School environments can further mediate the impact of sociocultural and environmental factors on math anxiety (Ainscow, Booth, & Dyson, 2006; Chang & Beilock, 2016; Reid & Reid, 2022; Luttenberger, Wimmer, & Paechter, 2018). Inclusive education frameworks highlight the importance of building and maintaining equitable learning spaces where systemic barriers are addressed, challenged, and all students can participate fully and meaningfully in mathematical learning (Ainscow, Booth, & Dyson, 2006). Reid and Reid (2022) emphasize that math identity is socially constructed and shaped by educator beliefs, classroom dynamics, and systemic inequities such as socio-economic status and gender. Students in math classrooms that lack supportive structures or positive math cultures are more likely to experience greater anxiety, which can impair working memory and hinder performance in math but other subject areas as well (Chang & Beilock, 2016; Rucchin, 2020). Creating dynamic and collaborative learning communities, therefore, is clearly critical for reducing math anxiety and fostering confidence and engagement among diverse learners (Luttenberger, Wimmer, & Paechter, 2018).

It should also be noted that the literature states that cultural and systemic norms also contribute to persistent disparities in math attitudes and achievement across levels (Beilock et al., 2010; Dweck, 2006; Eccles, 2011; Gunderson, Ramirez, Levine, & Beilock, 2012; Luttenberger, Wimmer, & Paechter, 2018). Gendered expectations, societal and cultural stereotypes, and adult modeling of math anxiety can combine to limit students' perceptions of their own abilities and influence their educational trajectories in our schools (Gunderson, Ramirez, Levine, & Beilock, 2012; Paulos, 2001). Dweck's (2006) research on mindset underscores that students' beliefs about intelligence - shaped by both socialization and environmental cues - can impact motivation, resilience, and engagement in math. When students encounter environments that reinforce fixed beliefs about ability or fail to acknowledge sociocultural influences, math anxiety is likely to increase and intensify, with potentially long-term consequences for educational and career choices for students (Luttenberger et al., 2018; Eccles, 2011). In combination, these scholarly studies reinforce and highlight that addressing math anxiety requires interventions targeting not only individual cognitive and emotional factors but also the broader sociocultural and environmental contexts in which learning occurs (Beilock et al., 2010; Chang & Beilock, 2016; Cohen & Rubinsten, 2017; Reid & Reid, 2022; Szczygieł, 2020).

Teaching, Learning, and Math Anxiety

Research on math anxiety consistently highlights the integral role of teaching practices and classroom environments in shaping students' emotional and cognitive experiences with mathematics education. Beilock and Willingham's research identify math anxiety as both a cognitive and affective need that can impact working memory and problem-solving skills and abilities, particularly in high-pressure situations (2014). There is an emphasis on teacher attitudes toward mathematics which strongly influences student confidence and performance, with anxious teachers potentially often inadvertently transmitting their own discomfort onto learners (Beilock & Willingham, 2014). Similarly, Kunwar describes how poor instructional strategies, negative reinforcements, and too rigid curriculum expectations can exacerbate "arithmophobia," or fear of numbers (2020). Together, these findings underscore the need for pedagogical approaches that reduce pressure, normalize and accept mistakes, and strengthen foundational understanding to build both competence and confidence in mathematics teaching and learning (Beilock & Willingham, 2014; Kunwar, 2020).

A central component of reducing math anxiety in classrooms involves fostering positive mindsets and emotionally safe classroom environments. Researcher Boaler advocates for a growth mindset approach, where students are encouraged to view mathematical ability as developable through effort and creativity rather than innate talent (2015). This perspective further aligns with Duncan's (2021) research on emotionally supportive learning spaces, which demonstrates that classrooms characterized by structure, empathy, and autonomy promote deeper mathematical engagement and resilience. When students perceive their environment as emotionally safe, they are more likely to take intellectual risks and engage productively with challenging content (Beilock & Willingham, 2014; Kunwar, 2020). Such approaches align with social-emotional learning (SEL) frameworks, positioning emotional safety as a prerequisite for meaningful cognitive engagement and mathematical reasoning (Duncan, 2021; Hattie, 2009).

Effective instructional strategies and leadership support further contribute to reducing math anxiety and enhancing learning outcomes (Beilock & Willingham, 2014; Boaler, 2015). Hattie's (2009) meta-analyses reveal that teacher clarity, feedback, and student self-efficacy are among the most influential factors on achievement. Complementing these findings, Small (2010) and Lawson (2015) provide practical frameworks for differentiated instruction that meet diverse learner needs through open-ended questioning and developmental continua. These strategies promote inclusivity and help students experience success at their own pace, mitigating anxiety through achievable challenges. Ferguson (2020) adds that systemic change - through collaboration between educators and leaders - supports sustainable numeracy growth and helps embed evidence-based practices school-wide. Collectively, this literature illustrates that reducing math

anxiety requires a multifaceted approach: one that integrates emotional support, instructional clarity, growth-oriented pedagogy, and collaborative leadership to create environments where all students can thrive in mathematics (Beilock & Willingham, 2014; Boaler, 2015; Duncan, 2021).

Discussion

The findings of this literature review reveal several notable gaps in the current research on math anxiety that have implications for both educational research but also classroom practice. While much of the existing literature has focused on cognitive and affective aspects of math anxiety, fewer studies have examined the interaction between sociocultural factors and individual learner differences, such as the impact of gender, socio-economic status, or culturally specific learning environments. Furthermore, there is a lack of scholarly literature around the role of math coaching in regard to math anxiety. With many schools and school boards utilizing math coaches, understanding how math coaches can support students and teachers with math anxiety can be very helpful. Additionally, the majority of intervention research emphasizes short-term outcomes, leaving long-term efficacy and sustainability of strategies less researched. This gap suggests a need for studies that not only integrate cognitive, emotional, and sociocultural perspectives but also assess how interventions perform across diverse student populations and educational contexts looking at longer time periods. By addressing these limitations, future research could provide a more holistic understanding of math anxiety, guiding both theory development and practical approaches in classroom math instructional practices.

Identifying these gaps is also particularly valuable for educators seeking evidence-based strategies to support student learning and well-being in math specifically. For example, research that explicitly examines the alignment, or misalignment, between intervention strategies and classroom realities can help teachers implement approaches that are both effective and feasible in their everyday practice. Furthermore, understanding where the current research in this area is limited allows educators to make informed adaptations and innovations tailored to the unique and specific needs of their particular students. By attempting to bridge the divide between research and practice, targeted studies can generate actionable insights that enhance not only students' mathematical skills and development but also their confidence, engagement, and long-term educational trajectories in math related topics. In this way, highlighting gaps in the literature serves as both a roadmap for future scholarly research projects and a practical guide for educators striving to reduce the negative impacts of math anxiety in diverse learning environments.

Next Steps in Psychosociological Research

Much of the existing research on math anxiety originates from the field of educational psychology and mathematics educational research, which has been instrumental in deepening our understanding of the cognitive, emotional, and motivational factors that contribute to students' experiences with mathematics. Studies from this field have provided valuable insights into how math anxiety affects academic performance, self-efficacy, and learning behaviours, and have offered evidence-based strategies for impactful intervention. However, to gain a more holistic understanding of math anxiety, there is a growing need for research that also draws on sociological perspectives. Sociology can illuminate the broader social structures, systemic inequities, and cultural norms that shape how math anxiety is developed and experienced across different populations. By further investigating factors such as socioeconomic status, gender norms, institutional practices, peer dynamics, and family systems, sociological research can complement psychological findings and help address the structural barriers that affect not only students but also educators and families. Integrating both psychological and sociological approaches is essential to creating more equitable and effective educational environments.

Practical Teaching Implications

Given the far-reaching effects of math anxiety, it is critical that educators adopt impactful instructional practices that not only build mathematical competence but also address the emotional and psychological barriers to learning for various students (Beilock & Maloney, 2015). Creating safe and supportive classroom environments is equally important. Classrooms should foster a sense of psychological safety where students feel comfortable asking questions, expressing uncertainty, and learning from mistakes without fear of embarrassment. Instructional strategies like conferencing with students, think-pair-share, and anonymous polling can help reduce the performance pressure that often exacerbates math anxiety (Ashcraft & Krause, 2007). Alongside this, teachers should shift the instructional focus from speed and memorization to conceptual understanding. Timed tests and speed-based drills can increase anxiety and discourage deep engagement with mathematical ideas. Instead, focusing on problem-solving, multiple representations, and student-led inquiry promotes flexible thinking and deeper understanding (Ramirez et al., 2018).

In addition to academic strategies, incorporating mindfulness and self-regulation techniques can support students in managing math anxiety (Zuo & Wang, 2023). Brief breathing exercises or mindfulness moments before math instruction can calm students' nervous systems and improve focus (Zuo & Wang, 2023). Embedding emotional regulation strategies into math routines empowers students to persist through challenging tasks and

recognize anxiety as something that can be managed rather than avoided (Maloney & Beilock, 2012). At the same time, it is important that teachers themselves feel confident in their math teaching. Professional development that strengthens both content knowledge and pedagogical strategies for addressing math anxiety is essential. Teachers who are well-prepared and self-assured are more likely to model positive attitudes toward math and provide emotionally supportive instructional spaces (Beilock et al., 2010).

Finally, engaging families and communities in the effort to reduce math anxiety can extend support beyond the classroom. Many students internalize messages from home that reinforce negative attitudes toward math. Outreach efforts that demystify math and provide families with language and tools for positive reinforcement can help shift these narratives. By promoting a shared understanding of math as a subject that is accessible and valuable, families can become active partners in building student confidence and achievement (Chang & Beilock, 2016).

Conclusion

The examination of scholarly literature regarding math anxiety is essential to better understanding teaching practice and how educators, instructional leaders and coaches and researchers can better support students and teachers alike in this important subject area. Building on the identified gaps, future research should continue to prioritize longitudinal and mixed-methods studies that examine both the short- and long-term impacts of math anxiety and the interventions to improve math anxiety across diverse educational contexts. Scholars are encouraged to explore the nuanced and complex interplay of cognitive, emotional, and sociocultural factors to develop more comprehensive models of math anxiety that reflect the realities of the modern classroom dynamics. For educators, this information highlights the importance of integrating evidence-based teaching and learning practices, such as Hattie's High-Impact Instructional Practices, which can be adapted to meet individual student needs and address not only skill deficits but also affective and motivational dimensions (Hattie, 2017). By intentionally aligning research with classroom practice, both scholars and educational professionals can contribute to creating more positive and inclusive learning environments that foster mathematical confidence, resilience, and equity, ultimately supporting students' overall well-being and academic success in math and beyond.

While the importance of effective instructional practices and supporting students with math anxiety are both important topics, a bridge needs to be reinforced between these two important areas. Understanding the psychological, sociological and the pedagogical needs of students to best support their mathematics journey through K-12 education is essential in providing students with truly equitable and inclusive learning opportunities that are student-centered and responsive to individual needs. By integrating research on

cognitive and affective aspects of math anxiety along with evidence-based instructional strategies, educators can design learning experiences that not only build mathematical competence but also foster confidence, motivation, and resilience in this important area of education. This holistic approach to teaching and learning ensures that teaching practices address the academic, cognitive, social and emotional needs of students, promoting a learning environment where all students have the opportunity to succeed, engage meaningfully with content, and develop a positive relationship with the subject of mathematics throughout their educational journey.

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