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RESEARCH ARTICLE

MATHEMATICS ANXIETY CAUSES, CONSEQUENCES, AND COPING STRATEGIES

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Abstract

Mathematics anxiety is a common phenomenon that affects a significant portion of students and adults, hindering their ability to perform well in mathematical tasks and limiting their potential in related fields. This article explores the causes of mathematics anxiety, the various consequences it has on learners' academic and personal lives, and the coping strategies that have been shown to mitigate its impact. Through a literature review, we aim to provide a comprehensive understanding of how mathematics anxiety develops, its effects on performance, and practical approaches for educators and students to address it.

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Introduction:-

Mathematics anxiety is a widespread and often debilitating phenomenon that affects students at all educational levels, from primary school through to higher education (Ramirez et al., 2018). It is marked by sensations of fear, stress, and unease when confronted with mathematical tasks or simply the thought of participating in math-related activities. These emotional responses can lead to a range of negative outcomes, including avoidance of mathematics, reduced performance, and a general decline in self-confidence regarding mathematical ability (Ashcraft & Moore, 2009). While a certain degree of anxiety is a common experience in academic settings, mathematics anxiety stands out for its persistence and intensity, often hindering students' engagement with the subject and limiting their opportunities for success in a field that is foundational to many areas of study and future careers (Rozgonjuk et al., 2020).

In the context of mathematics education, anxiety can severely impair students' learning processes. Research shows that students with high levels of mathematics anxiety often struggle with basic mathematical concepts, making it difficult for them to progress to more advanced topics (Ramirez et al., 2018). This struggle is not simply a matter of poor grades; it involves a deeper cognitive and emotional disengagement from the subject. Students experiencing mathematics anxiety often report feelings of inadequacy, fear of failure, and a sense of helplessness in math-related tasks, which can further contribute to their difficulties (Pavelová et al., 2023). The problem is particularly concerning given that mathematical competency is essential not only for academic success but also for future career opportunities, especially in fields such as engineering, science, technology, and economics—areas that rely heavily on quantitative and analytical skills.

The roots of mathematics anxiety are complex and multifaceted, shaped by a variety of factors including early educational experiences, individual personality traits, and societal influences. Research has shown that negative experiences in early childhood education, such as struggling to keep up with peers or receiving discouraging feedback from teachers, can foster the development of anxiety toward mathematics (Hwang, 2024; Unamba et al.,

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2024). In certain instances, these feelings are intensified by a culture that suggests mathematics is naturally challenging or that some individuals are "born" with a greater aptitude for math than others. This mindset, often referred to as a fixed mindset, can prevent students from approaching mathematics with the confidence and perseverance needed for success. Additionally, societal and gender biases also play a significant role in shaping students' attitudes toward mathematics, with girls, in particular, being less likely to pursue mathematics-intensive fields due to the perception that they lack innate mathematical ability (Gutierrez Aguilar & Tejada, 2024).

In the classroom, mathematics anxiety manifests in a variety of ways, from physical symptoms such as sweating or a racing heart, to cognitive disruptions like blanking out during tests or forgetting learned concepts. These responses can create a feedback loop: students' anxiety inhibits their ability to perform well, which then reinforces their fear and avoidance of mathematics. Over time, this avoidance can become ingrained, with students disengaging not only from mathematics but also from other subjects that require mathematical reasoning, further narrowing their academic and career prospects. The stakes are high, as mathematics is a gateway subject for many disciplines, and anxiety in this area can limit a student's potential in education and beyond.

Despite the widespread nature of mathematics anxiety, it has been shown that effective intervention strategies can help students overcome or manage their fear of mathematics. Research on mathematics education has identified several approaches that can help mitigate the effects of anxiety and promote a more positive relationship with the subject. For example, interventions that focus on fostering a growth mindset—encouraging students to see mathematical ability as something that can be developed through effort and practice—have been shown to improve both students' attitudes toward mathematics and their academic performance (Balan & Sjöwall, 2022). Similarly, strategies that emphasize active learning, collaborative problem-solving, and real-world applications of mathematics can make the subject feel more relevant and approachable, reducing anxiety and increasing student engagement.

Furthermore, teacher attitudes and instructional practices play a pivotal role in shaping students' experiences with mathematics. Teachers who demonstrate patience, encouragement, and a willingness to support students through challenges are more likely to help mitigate mathematics anxiety (Khoudri, 2024). Research has also highlighted the importance of creating a classroom environment that promotes positive emotional experiences with mathematics—one that allows for mistakes, emphasizes effort over innate talent, and encourages a sense of mastery through consistent, incremental learning. By fostering a supportive and inclusive learning environment, educators can help students build the confidence needed to overcome their anxieties and succeed in mathematics.

This paper seeks to explore the causes and consequences of mathematics anxiety in the context of mathematics education. It will review the existing literature on the topic, examining the psychological, social, and cognitive factors that contribute to the development of anxiety in mathematical learning. The paper will also analyze the impact of mathematics anxiety on students' academic achievement, motivation, and long-term engagement with the subject. Finally, the paper will propose and evaluate various evidence-based strategies for alleviating mathematics anxiety, drawing on research that has demonstrated their effectiveness in educational settings. By exploring the issue of mathematics anxiety within the framework of mathematics education, this paper aims to offer practical solutions and insights that can inform teaching practices and support the development of more inclusive, effective, and empathetic mathematics curricula. The ultimate goal is to help foster a learning environment where all students, regardless of their prior experiences with the subject, can approach mathematics with confidence, resilience, and a willingness to engage with the subject in meaningful ways.

Causes of Mathematics Anxiety

Mathematics anxiety is a complex psychological condition that emerges from a confluence of cognitive, emotional, and environmental factors. These factors interact in ways that create a deeply ingrained fear or apprehension toward engaging with mathematics, which can persist well into adulthood. A closer examination of the literature reveals several key causes of mathematics anxiety, each contributing in its own way to the development of this debilitating condition.

Early Experiences with Mathematics

Many students begin to develop negative associations with mathematics early in their academic careers (Krinzinger et al., 2009; Wan et al., 2021). The early stages of schooling, particularly in elementary and middle school, often involve foundational concepts such as basic arithmetic and number recognition. It is during this time that students are most vulnerable to developing anxiety, especially when they struggle with these basic skills. Failure to grasp

early mathematical concepts or difficulties in keeping up with peers can lead to frustration, feelings of inadequacy, and a lack of confidence. These initial struggles often set the stage for long-term negative attitudes toward the subject.

Research by Ramirez et al. (2018) highlights how early difficulties in mastering fundamental arithmetic concepts, such as addition and subtraction, can be a significant contributor to lifelong mathematics anxiety. Ramirez argues that negative experiences with basic math tasks are often internalized, creating a sense of helplessness and fear that persists through later academic years. These early experiences, particularly if accompanied by negative feedback from teachers or peers, can cause students to associate mathematics with failure, rather than a challenge to be overcome. Over time, these negative associations become reinforced, making it harder for students to engage with math in a positive and constructive way.

Parental and Societal Expectations

Another significant factor contributing to mathematics anxiety is the pressure placed on students by both parents and society to excel in mathematics. In many cultures, mathematics is viewed not only as a critical academic subject but also as a measure of intelligence and future success. This can create immense pressure for students, who may begin to perceive mathematics as a high-stakes subject that can determine their future academic and professional opportunities. The weight of these expectations can exacerbate feelings of anxiety and stress, particularly among students who struggle with the subject.

Research by Macmull & Ashkenazi (2019) emphasizes the role of parental pressure in the development of mathematics anxiety. Macmull & Ashkenazi found that students who experience high levels of parental expectation, particularly those who are constantly compared to peers or older siblings, tend to develop higher levels of anxiety. The constant pressure to perform can lead to an unhealthy focus on the outcome—grades or test scores—rather than the learning process itself. This mindset can fuel a fear of failure, especially when students feel that any mistakes or setbacks will result in disappointment from their parents. As a result, students may come to fear mathematics not only because of their own perceived shortcomings but also because of the societal and familial expectations placed upon them.

Gender Stereotypes and Cultural Factors

Gender stereotypes play a crucial role in shaping attitudes toward mathematics, particularly among girls. Cultural norms often portray mathematics as a male-dominated field, with boys being seen as "naturally" better at math than girls. This stereotype, which is pervasive in many societies, can have a profound effect on girls' confidence and performance in the subject. When girls internalize these gendered beliefs, they may develop a sense of inadequacy or doubt regarding their mathematical abilities, leading to increased anxiety.

Studies by Vanbinst et al. (2020) reveal that girls often experience higher levels of mathematics anxiety than boys, largely due to societal expectations and stereotypes about gender and intelligence. These stereotypes, which are often reinforced by teachers, parents, and peers, contribute to the underperformance of girls in mathematics. Moreover, research has shown that when girls perceive mathematics as an "elite" or "challenging" subject—one that is only accessible to a select group of people—they may withdraw from the subject altogether. This creates a vicious cycle, where anxiety, combined with societal pressures, prevents girls from engaging with mathematics and pursuing careers in STEM fields.

Cultural perceptions of mathematics as an inherently "difficult" subject also contribute to the development of anxiety. In some societies, math is seen as a subject reserved for those with exceptional intelligence or talent, and this perception can discourage students who struggle with math from persevering. This belief in the "fixed" nature of mathematical ability—where some students are simply "good at math" while others are not—can be a barrier to developing a growth mindset and overcoming anxiety.

Cognitive Factors

Cognitive factors also play a significant role in the development of mathematics anxiety. Research has shown that individuals with lower self-efficacy in mathematics—those who do not believe in their own ability to succeed—are more likely to experience anxiety (Rozgonjuk et al., 2020). Self-efficacy, or the belief in one's ability to perform tasks successfully, is a crucial component in overcoming challenges. When students lack confidence in their mathematical abilities, they are more prone to feeling overwhelmed and anxious when faced with math-related tasks.

Additionally, cognitive processing issues, such as difficulties with working memory, attention, and processing speed, can exacerbate feelings of anxiety. Students who struggle with mental calculation, problem-solving, or processing mathematical information may become easily frustrated, especially when they encounter complex or unfamiliar concepts. Petronzi et al. (2021) argues that the cognitive demands of mathematics—such as the need for quick mental calculations, the ability to follow complex logical steps, and the use of abstract reasoning—can trigger anxiety in students who have difficulty with these cognitive skills. For these students, the experience of "blinking out" or failing to recall mathematical concepts during a test or problem-solving task can be a source of considerable stress, reinforcing their anxiety and avoidance of mathematics.

The cognitive aspect of mathematics anxiety can be particularly insidious, as it often leads to a cycle of avoidance and low performance. Students who struggle with mathematics may avoid math-related tasks or skip math classes, reinforcing their belief that they are incapable of succeeding. Over time, these cognitive and emotional responses can become ingrained, making it increasingly difficult for students to break free from their anxiety.

Consequences of Mathematics Anxiety

The consequences of mathematics anxiety extend far beyond poor performance in math classes. While academic underachievement is perhaps the most immediate and visible consequence, the effects of mathematics anxiety can be long-lasting and pervasive, impacting students' emotional well-being, career choices, and overall life trajectory.

Academic Performance

One of the most direct consequences of mathematics anxiety is poor academic performance. Students with high levels of anxiety often experience difficulties in completing math assignments, participating in math discussions, or performing well on assessments. This anxiety-driven avoidance behavior can result in lower test scores and diminished academic achievement, even if the student possesses the necessary cognitive abilities. Devine et al. (2012) conducted studies that demonstrated a clear correlation between mathematics anxiety and lower math test scores. This avoidance of math, coupled with the negative emotional responses that arise from testing situations, creates a feedback loop that further entrenches the anxiety and diminishes the student's ability to succeed.

Long-Term Impact on Career Choices

The long-term effects of mathematics anxiety are particularly concerning when it comes to career aspirations. Students who experience persistent mathematics anxiety are more likely to avoid pursuing careers that require strong mathematical skills, such as those in engineering, technology, finance, or other STEM fields. This avoidance is not just a reflection of the students' current academic struggles but also an internalized belief that they are incapable of succeeding in these fields.

According to Eidlin-Levy et al. (2023), individuals with high levels of mathematics anxiety are less likely to pursue STEM careers, even when they have the necessary qualifications. This is particularly problematic given the increasing demand for professionals in STEM fields and the significant gender disparities that already exist in these areas. The avoidance of mathematics-related careers due to anxiety contributes to the underrepresentation of women and other marginalized groups in these critical fields.

Emotional and Psychological Effects

Finally, the emotional and psychological toll of mathematics anxiety can have far-reaching consequences for students' overall well-being. The stress and fear associated with mathematics can lead to lower self-esteem, decreased motivation, and a diminished sense of self-efficacy. In severe cases, mathematics anxiety has been linked to symptoms of depression, generalized anxiety disorder, and other mental health issues (Wu et al., 2014). The long-term emotional impact of anxiety can lead to a pervasive sense of failure, creating a barrier not only to academic success but also to personal growth and confidence. This negative emotional cycle often becomes self-reinforcing, as the anxiety continues to hinder the student's ability to succeed, leading to further feelings of inadequacy and distress.

Coping Strategies for Mathematics Anxiety

Mathematics anxiety is a challenging and pervasive condition, but there are a variety of coping strategies that have been identified through research to help individuals manage or even overcome their fear of mathematics. These strategies range from psychological interventions, such as cognitive-behavioral therapy (CBT), to changes in the classroom environment that promote a more supportive and less stressful approach to learning mathematics. As

research continues to develop in this area, several evidence-based approaches have shown promise in reducing anxiety, building confidence, and improving performance in mathematics.

Cognitive-Behavioral Therapy (CBT)

One of the most well-established approaches for managing mathematics anxiety is Cognitive-Behavioral Therapy (CBT). CBT is a therapeutic approach that focuses on identifying and challenging negative thought patterns and replacing them with more realistic and constructive ways of thinking. In the context of mathematics anxiety, CBT techniques like cognitive restructuring and exposure therapy have been found to be highly effective in helping individuals reframe their beliefs about mathematics and reduce their anxiety.

Cognitive restructuring involves helping individuals identify negative or irrational thoughts, such as "I'm just not good at math" or "I'll never be able to understand this," and replacing them with more positive and realistic beliefs, such as "I can improve with practice" or "It's okay to make mistakes in the learning process." This technique helps to shift the focus from a fear of failure to a mindset of growth and improvement.

Exposure therapy is another key CBT technique that can help desensitize individuals to the anxiety-inducing aspects of mathematics. In exposure therapy, students gradually and systematically expose themselves to math-related situations—starting with less challenging tasks and progressively working their way up to more difficult ones. This process helps individuals confront their fears in a controlled and supportive environment, ultimately reducing the emotional intensity associated with mathematical tasks.

Research by Asanjarani & Zarebaramabadi (2021) demonstrates the effectiveness of CBT in reducing math anxiety. The study showed that university students who participated in a CBT intervention experienced significant reductions in their anxiety levels and demonstrated improved performance in math-related tasks. These findings highlight the power of cognitive-behavioral approaches in addressing the root causes of mathematics anxiety and promoting more positive attitudes toward the subject.

Mindfulness and Relaxation Techniques

Another promising set of coping strategies for mathematics anxiety involves mindfulness and relaxation techniques. These approaches aim to help students manage their anxiety in high-stress situations, such as math tests or difficult problem-solving tasks, by fostering a state of calm awareness and reducing physiological symptoms of stress.

Mindfulness meditation is a practice that encourages individuals to stay present in the moment, without judgment, while observing their thoughts and emotions without becoming consumed by them. This practice can help students become more aware of the anxiety-provoking thoughts they may have about mathematics and allow them to detach from these thoughts, rather than becoming consumed by them.

Other relaxation techniques, such as **deep breathing** and **progressive muscle relaxation**, help individuals calm their physiological responses to anxiety. Deep breathing exercises can slow the heart rate and reduce muscle tension, while progressive muscle relaxation involves tensing and relaxing different muscle groups to help release physical tension associated with stress.

Research by Hofmann et al. (2010) shows that mindfulness and relaxation practices can significantly reduce the physiological symptoms of anxiety, such as sweating, racing heart, and shallow breathing, which often accompany math-related stress. By using these techniques, students can experience greater calmness and focus during math tasks, leading to improved performance and a reduction in their anxiety levels.

Positive Reinforcement and Encouragement

In addition to individual psychological interventions, the role of educators in creating a supportive and encouraging learning environment cannot be overstated. Teachers have the power to significantly influence students' experiences with mathematics by fostering a positive classroom atmosphere where mistakes are viewed as learning opportunities rather than failures.

One key strategy for reducing mathematics anxiety is the use of positive reinforcement. When students are provided with constructive feedback that focuses on effort, progress, and persistence, rather than just results, they are more

likely to feel confident in their abilities. Encouraging students to focus on the learning process and celebrate small successes can build their self-esteem and help them develop a sense of mastery over time.

The concept of a growth mindset, popularized by psychologist Carol Dweck(2006), is particularly relevant to mathematics education. A growth mindset emphasizes the belief that abilities and intelligence can be developed through effort and persistence, rather than being fixed traits. By encouraging students to view challenges as opportunities for growth and learning, teachers can reduce the fear of failure that often underlies mathematics anxiety. Dweck's research demonstrated that students who were encouraged to adopt a growth mindset were less likely to develop mathematics anxiety and more likely to engage positively with the subject.

Peer Support and Collaborative Learning

Incorporating peer support and collaborative learning into the mathematics classroom can also help alleviate anxiety. When students work together to solve problems or discuss mathematical concepts, they often feel less isolated and more supported. Collaborative learning allows students to share their ideas and approaches, which can build their confidence and foster a sense of community.

Research by Siller (2024) highlights the benefits of collaborative problem-solving in reducing math anxiety. Their study found that students who engaged in group work or peer tutoring were less likely to experience feelings of isolation or inadequacy in math. Working together allows students to see that others may share similar struggles and that overcoming these challenges is possible with support. Peer tutoring, in particular, has been shown to be effective in lowering anxiety levels, as students often feel more comfortable asking questions and expressing confusion to their peers than to a teacher.

In a peer-supported learning environment, students can also help each other build confidence by explaining concepts in ways that are more relatable to their peers. This process reinforces their own understanding while fostering a collaborative and less competitive atmosphere. Group work can create a more relaxed, non-threatening environment, which is particularly beneficial for students who experience anxiety when working independently.

Educational Interventions and Curriculum Changes

Finally, educational interventions and curriculum changes that focus on making mathematics more engaging and less anxiety-inducing can play a crucial role in mitigating mathematics anxiety. Traditional mathematics teaching methods, which often emphasize rote memorization and procedural drills, can create a stressful learning environment where students feel pressured to memorize formulas and solve problems quickly. In contrast, interventions that emphasize understanding, critical thinking, and real-world applications of mathematics can help students develop a more positive relationship with the subject.

Programs such as Math Circles or Inquiry-Based Learning are examples of creative methods that have proven effective in reducing anxiety by fostering a deeper understanding and greater involvement with mathematics. Math Circles are informal gatherings where students work on interesting and challenging mathematical problems in a collaborative, exploratory setting. These programs encourage curiosity and foster a sense of excitement around mathematics, rather than focusing solely on grades or test performance. By providing students with opportunities to explore math in a more relaxed, interactive environment, they are more likely to develop a love for the subject and feel less anxious about encountering challenges.

Inquiry-Based Learning (IBL), in contrast, focuses on student-led exploration and the process of solving problems. In IBL classrooms, students are encouraged to ask questions, investigate problems, and collaborate to find solutions. This approach allows students to engage with math in a more meaningful and context-driven way, helping them develop critical thinking skills while reducing the pressure associated with traditional, test-focused teaching methods. Research by Boaler (2016) has shown that programs like Math Circles and Inquiry-Based Learning significantly reduce students' anxiety and foster a more positive, confidence-building approach to mathematics.

Conclusion:-

Mathematics anxiety represents a significant and pervasive barrier to learning, with far-reaching consequences that extend across all levels of education and into professional and personal life. The impact of this anxiety is particularly concerning as mathematics is a critical skill that influences not only academic success but also future career opportunities in a wider range of fields, particularly those that are math-

intensive, such as engineering, technology, finance, and the sciences. Despite the widespread nature of mathematics anxiety, it is not an insurmountable challenge. By understanding the multifaceted causes, consequences, and coping strategies, educators, students, and policymakers can work together to reduce the prevalence and impact of this anxiety.

Through research and clinical studies, it has become clear that mathematics anxiety arises from a complex interplay of cognitive, emotional, societal, and environmental factors. These include early negative experiences with math, societal and parental expectations, gender stereotypes, and cognitive challenges such as low self-efficacy. Additionally, the consequences of mathematics anxiety are far-reaching, affecting not only academic performance but also career trajectories and emotional well-being. Students experiencing high levels of math anxiety may avoid mathematics altogether, which limits their career options and contributes to the gender and diversity gaps in STEM (Science, Technology, Engineering, and Mathematics) fields.

However, it is important to recognize that there is hope for individuals struggling with this anxiety. Various coping strategies have proven effective in helping students manage and overcome their fears. Among these, cognitive-behavioral therapy (CBT) stands out as a particularly effective approach. Techniques such as cognitive restructuring and exposure therapy allow students to challenge and reframe their negative beliefs about mathematics, replacing them with healthier, more constructive thoughts. CBT interventions have been shown to significantly reduce math anxiety, improving both emotional well-being and academic performance.

In addition to CBT, mindfulness and relaxation techniques offer valuable tools for managing the physiological and emotional symptoms of anxiety. Mindfulness practices, including meditation and deep breathing, help students become more aware of their anxiety triggers and learn to manage their stress responses. These techniques, when combined with strategies such as positive reinforcement from educators and collaborative learning environments, help to foster a supportive and less intimidating atmosphere in the classroom. Creating a classroom culture where students are encouraged to see mistakes as part of the learning process, rather than failures, is essential for building self-confidence and reducing the fear of mathematics.

Equally important are peer support systems and collaborative learning strategies, which can reduce feelings of isolation and help students build confidence in their mathematical abilities. Group problem-solving, peer tutoring, and study groups create opportunities for students to share ideas and approach problems together, which can lessen the anxiety associated with individual performance. Research has demonstrated that students who engage in collaborative learning are less likely to experience feelings of inadequacy or fear when working on math problems.

Curriculum innovation that emphasizes understanding over rote memorization and promote real-world applications of mathematics are also critical for reducing anxiety. Programs such as Math Circles or Inquiry-Based Learning have proven effective in encouraging active participation, fostering curiosity, and making mathematics more engaging and less intimidating. These approaches allow students to explore mathematics in a more hands-on, problem-solving manner, which helps them develop a deeper understanding of mathematical concepts and view math as a tool for solving real-world problems, rather than a collection of abstract and intimidating rules.

Despite the promising outcomes associated with these strategies, it is important to recognize that mathematics anxiety is a deeply entrenched issue that requires continued attention. While existing interventions have shown promise, more research is needed to refine and expand these approaches, ensuring they are universally accessible and tailored to meet the needs of diverse learners. For instance, further research into the effectiveness of specific cognitive-behavioral techniques, the impact of mindfulness on long-term anxiety reduction, and the ways in which cultural and societal factors influence mathematics anxiety will be invaluable in developing more nuanced and effective interventions. Additionally, exploring how these strategies can be integrated into teacher training programs and curriculum design will be essential for fostering widespread change in educational settings.

It is crucial that educators, policymakers, and researchers collaborate to create a systemic shift in how mathematics is taught and perceived. By embracing a holistic approach that includes both psychological interventions and changes to the classroom environment, we can begin to dismantle the barriers that mathematics anxiety creates. More importantly, fostering an environment in which students feel supported, encouraged, and confident in their ability to engage with mathematics will not only improve academic outcomes but also open up greater opportunities for success in fields that are crucial for the advancement of society.

Ultimately, addressing mathematics anxiety is about more than just improving academic performance—it is about empowering students to overcome their fears and develop the skills and confidence necessary for success, not just in mathematics but in life. By equipping students with the tools to manage anxiety, fostering a growth mindset, and ensuring equitable access to supportive learning environments, we can help ensure that all learners—regardless of background or ability—have the opportunity to thrive in mathematics and beyond. Through continued research, collaboration, and innovation, it is possible to create a future where mathematics is no longer a source of anxiety, but a subject that inspires curiosity, confidence, and lifelong learning.

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