

Emotional and Cognitive Predictors of Math Anxiety: The Influence of Self-Efficacy, Mindfulness, and Self-Compassion

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Abstract

Math anxiety is a significant barrier to academic achievement, particularly for students in mathematics-intensive fields. This study examines the emotional and cognitive predictors of math anxiety, focusing on the roles of self-efficacy, mindfulness, and self-compassion among undergraduate mathematics students from public and private universities in Lahore. A sample of 300 students completed validated measures of math anxiety, self-efficacy, mindfulness, and self-compassion. Correlational analyses revealed significant negative relationships between math anxiety and self-efficacy ($r=-0.48, p<.01, r = -0.48, p < .01, r=-0.48, p<.01$), mindfulness ($r=-0.22, p<.01, r = -0.22, p < .01, r=-0.22, p<.01$), and self-compassion ($r=-0.31, p<.01, r = -0.31, p < .01, r=-0.31, p<.01$). Hierarchical multiple regression indicated that self-efficacy was the strongest predictor of math anxiety ($B=-0.82, p<.001, B = -0.82, p < .001, B=-0.82, p<.001$), accounting for a significant portion of the variance ($R^2=.28, R^2 = .28, R^2=.28$). Self-compassion also significantly predicted lower levels of math anxiety ($B=-0.36, p<.05, B = -0.36, p < .05, B=-0.36, p<.05$), while mindfulness had minimal, non-significant effects ($B=-0.03, p>.05, B = -0.03, p > .05, B=-0.03, p>.05$). These findings highlight the importance of self-efficacy and self-compassion in reducing math anxiety. Educational interventions that focus on enhancing students' self-efficacy and promoting self-compassion may be particularly effective in mitigating math anxiety and improving academic performance. Future research should explore the mechanisms through which these emotional and cognitive factors interact to influence anxiety in mathematics learning.

keywords: Math Anxiety, Self-Efficacy, Mindfulness, Self-Compassion, Undergraduate Mathematics Students

Introduction

Mathematics plays a fundamental role in academic and professional success, particularly in science, technology, engineering, and mathematics (STEM) fields. However, for many students, the subject is a source of significant distress, manifesting as math anxiety (MA). Math anxiety is characterized by feelings of tension, apprehension, or fear that interfere with math performance (Ashcraft & Ridley, 2005). A growing body of literature has demonstrated the detrimental effects of math anxiety on students' performance, motivation, and academic outcomes (Beilock & Maloney, 2015). Understanding the predictors of math anxiety is crucial for educators and researchers aiming to develop interventions to mitigate its negative impacts. Among the various emotional and cognitive factors, self-efficacy, mindfulness, and self-compassion have emerged as significant predictors of math anxiety, influencing how students perceive and approach mathematical tasks.

Math Anxiety: A Barrier to Learning: Math anxiety has long been recognized as a pervasive issue affecting students across different educational levels (Wang et al., 2015). Research has consistently shown that math anxiety can impair both short-term math performance and long-term academic engagement, particularly in STEM fields (Beilock & Willingham, 2014). Neuroscientific evidence suggests that math anxiety disrupts cognitive processes by overwhelming working memory resources, which are crucial for solving mathematical problems (Young, Wu, & Menon, 2012). This cognitive burden creates a feedback loop where poor performance heightens anxiety, further inhibiting learning (Carey et al., 2016).

Math anxiety is not merely an academic issue but also an emotional experience tied to students' beliefs about their abilities and emotional regulation strategies. Recent studies have focused on the emotional and cognitive predictors of math anxiety, identifying self-efficacy, mindfulness, and self-compassion as key factors that could mitigate its effects (Zhang et al., 2019; Samuel & Warner, 2021).

Self-Efficacy as a Predictor of Math Anxiety: Self-efficacy, a concept derived from Bandura's (1997) social cognitive theory, refers to an individual's belief in their ability to succeed in specific tasks. Self-efficacy is one of the most studied predictors of math anxiety, with numerous studies demonstrating its inverse relationship with anxiety levels (Akin & Kurbanoglu, 2011; Ramos-Salazar, 2018). According to Bandura (1997), individuals with high self-efficacy are more likely

to approach difficult tasks as challenges to be mastered rather than threats to be avoided, which directly influences their emotional responses to those tasks.

In the context of mathematics, students with higher self-efficacy tend to exhibit lower levels of math anxiety and perform better in math-related tasks (Usher & Pajares, 2009). A meta-analysis by Huang (2013) found that math self-efficacy is one of the strongest predictors of math performance and persistence in math-related fields. Conversely, students with low self-efficacy in mathematics are more likely to experience math anxiety, avoid math courses, and perform poorly in math exams (McMullan, Jones, & Lea, 2012).

Recent studies have expanded on this relationship by examining the mechanisms through which self-efficacy influences math anxiety. Samuel and Warner (2021) conducted a longitudinal study with first-year college students and found that students with higher self-efficacy were better able to regulate their emotional responses to math-related stressors, thereby reducing anxiety over time. Similarly, Pajares and Kranzler (2014) suggest that interventions aimed at boosting math self-efficacy, such as mastery experiences and positive feedback, can significantly reduce math anxiety in students.

Mindfulness and Math Anxiety: Mindfulness has gained considerable attention in recent years as a tool for reducing anxiety and improving cognitive functioning (Shapiro et al., 2015). Defined as the non-judgmental awareness of the present moment, mindfulness allows individuals to disengage from automatic thoughts and emotions that may exacerbate anxiety (Kabat-Zinn, 2005). In academic contexts, mindfulness has been shown to enhance cognitive performance by improving attention, working memory, and emotional regulation (Zeidan et al., 2010).

Emerging research suggests that mindfulness may also play a role in reducing math anxiety. A study by Brunyé et al. (2013) found that a brief mindfulness-based breathing exercise reduced anxiety and improved math performance in students with high levels of math anxiety. This finding was supported by LaGue et al. (2020), who demonstrated that high school students participating in mindfulness-based cognitive therapy reported significantly lower levels of math anxiety after the intervention. The authors suggest that mindfulness reduces the cognitive load associated with anxiety by helping students focus on the task at hand rather than ruminating on their fears of failure. Mindfulness has also been linked to improved executive functioning, which is critical for mathematical problem-solving (Beilock & Maloney, 2015). Studies have shown that mindfulness practice enhances working memory capacity, attention control, and emotional regulation, all of

which are essential for managing the stress associated with math anxiety (Flook et al., 2010). However, not all research has found mindfulness to be a significant predictor of math anxiety. For example, while Zhang et al. (2019) reported a significant negative correlation between mindfulness and math anxiety, mindfulness accounted for only a small portion of the variance in their predictive model. These mixed findings suggest that while mindfulness may help alleviate math anxiety, its effects may depend on the specific mindfulness practices used and the individual's baseline anxiety levels.

Self-Compassion and Math Anxiety: Self-compassion, a construct closely related to mindfulness, has also been identified as a potential buffer against math anxiety. Self-compassion involves treating oneself with kindness and understanding in the face of failure or difficulty, rather than being overly critical or self-judgmental (Neff, 2003). Self-compassion has been associated with lower levels of anxiety, depression, and stress across various populations (Neff et al., 2005). In the academic domain, self-compassion helps students cope with academic setbacks, reducing fear of failure and promoting resilience (Neff & Germer, 2013).

Although the relationship between self-compassion and math anxiety is still underexplored, recent studies suggest that self-compassion may serve as a protective factor against the negative emotional states that contribute to math anxiety (Manavipour & Saeedian, 2016). Hayes et al. (2016) found that college students with higher self-compassion scores reported lower levels of general anxiety and academic distress, which suggests that self-compassion may help mitigate the effects of math anxiety. Akin (2008) also found that self-compassion was positively associated with learning goal orientations and negatively associated with performance goal orientations, which could reduce the fear of failure that often exacerbates math anxiety.

Moreover, Neff et al. (2005) proposed that self-compassion fosters intrinsic motivation and mastery goals, which are key factors in academic success. By promoting a more adaptive response to failure, self-compassion may encourage students to persist in the face of math-related challenges, thereby reducing anxiety. Given the growing interest in self-compassion as a psychological resource, further research is needed to understand its role in alleviating math anxiety specifically.

The Interplay of Self-Efficacy, Mindfulness, and Self-Compassion: While self-efficacy, mindfulness, and self-compassion have been individually studied as predictors of math anxiety, there is limited research examining their combined effects. These constructs likely interact in

complex ways to influence how students perceive and cope with math-related stress. For instance, students with high self-efficacy may be more likely to engage in mindfulness practices, which in turn enhance their emotional regulation skills and reduce anxiety (Samuel & Warner, 2021). Similarly, self-compassion may moderate the relationship between self-efficacy and math anxiety by helping students reframe failures as learning opportunities rather than indicators of incompetence (Manavipour & Saeedian, 2016).

This study aims to explore how self-efficacy, mindfulness, and self-compassion together predict math anxiety in undergraduate mathematics students. By understanding the interplay between these emotional and cognitive factors, educators and psychologists can develop more effective interventions to reduce math anxiety and improve students' academic outcomes.

Research Methodology

Participants: Participants in this study were drawn from the Mathematics Departments of various private and public sector universities located in Lahore, Pakistan. The sample consisted of 300 undergraduate students majoring in mathematics. The exclusion criteria were set to ensure that only mathematics students were included, removing any participants from non-mathematical disciplines. Participants were recruited voluntarily through university email invitations and classroom announcements. Informed consent was obtained from all participants, and the study was conducted in accordance with ethical guidelines and approved by the institutional review board.

Measures: To investigate the emotional and cognitive predictors of math anxiety, three validated instruments were employed: the Abbreviated Mathematics Anxiety Rating Scale (AMARS), the Self-Efficacy for Learning and Performance Subscale (SELPS) from the Motivated Strategies for Learning Questionnaire (MSLQ), the Five Facet Mindfulness Questionnaire (FFMQ), and the Self-Compassion Scale-Short Form (SCS-SF).

Abbreviated Mathematics Anxiety Rating Scale (AMARS): Math anxiety was measured using the Abbreviated Mathematics Anxiety Rating Scale (AMARS) developed by Alexander and Martray (1989). This scale is an abridged version of the full Mathematics Anxiety Rating Scale (MARS) and consists of 25 items that assess different dimensions of math anxiety, such as mathematics exam anxiety, numerical task anxiety, and mathematics course anxiety. The AMARS uses a 5-point Likert scale ranging from 1 = not at all anxious to 5 = very anxious, with higher scores indicating greater levels of math anxiety.

This scale has been validated across various student populations and has shown high internal consistency, with a Cronbach's alpha of .96 in the current study, indicating excellent reliability.

Self-Efficacy for Learning and Performance Subscale (SELPS): The Self-Efficacy for Learning and Performance Subscale (SELPS) is part of the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich and De Groot (1990). This 8-item subscale is designed to assess students' beliefs in their ability to successfully complete tasks and perform well in academic activities. The items are rated on a 7-point Likert scale from 1 = not at all true of me to 7 = very true of me.

The total score ranges from 8 to 56, with higher scores reflecting greater self-efficacy. This scale has been widely used in educational settings and has shown robust psychometric properties. In the current study, the Cronbach's alpha for this subscale was .96, indicating high reliability.

Five Facet Mindfulness Questionnaire (FFMQ): Mindfulness was assessed using the Five Facet Mindfulness Questionnaire (FFMQ) developed by Baer et al. (2006). This instrument consists of 39 items that measure five distinct facets of mindfulness: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. Each item is rated on a 5-point Likert scale ranging from 1 = never or very rarely true to 5 = very often or always true.

The total score for mindfulness ranges from 39 to 195, with higher scores indicating greater levels of mindfulness. The FFMQ has demonstrated strong internal consistency across different populations. For this study, the Cronbach's alpha was .83, which is considered good.

Self-Compassion Scale-Short Form (SCS-SF): Self-compassion was measured using the Self-Compassion Scale-Short Form (SCS-SF) developed by Raes et al. (2011). The SCS-SF is a 12-item scale that assesses three core components of self-compassion: self-kindness, common humanity, and mindfulness, each of which has corresponding subscales. The items are rated on a 5-point Likert scale, with responses ranging from 1 = almost never to 5 = almost always.

The scale yields a total score between 12 and 60, with higher scores indicating greater self-compassion. This scale has been validated in numerous studies and has shown excellent internal consistency. In this study, the Cronbach's alpha was .83.

Procedure: After obtaining ethical approval, data were collected through an online survey platform. Participants were provided with an informed consent form outlining the purpose of the study, their rights as participants, and assurance of confidentiality. They were asked to complete

the survey during their free time, and participation was voluntary. The survey included the four instruments outlined above: the AMARS, SELPS, FFMQ, and SCS-SF. The survey took approximately 20-30 minutes to complete. Students were encouraged to answer all questions truthfully, and they were assured that there were no right or wrong answers.

Results and Data Analysis

Data were analyzed using IBM SPSS Statistics 26. Pearson correlation analysis was conducted to examine the relationships between math anxiety, self-efficacy, mindfulness, and self-compassion. Hierarchical multiple regression analysis was used to determine the predictive power of self-efficacy, mindfulness, and self-compassion on math anxiety. self-efficacy, mindfulness, and self-compassion were entered as predictors to assess their unique contributions to explaining the variance in math anxiety scores. Preliminary analyses, including checks for normality, multicollinearity, and homoscedasticity, were conducted to ensure that the assumptions of regression analysis were met. No significant violations were detected, and the regression model was deemed appropriate for the data.

Table 1 presents the correlations between math anxiety, self-efficacy, mindfulness, and self-compassion. As shown, math anxiety was significantly negatively correlated with self-efficacy ($r = -0.48$, $r = -0.48$, $r = -0.48$, $p < .01$, $p < .01$, $p < .01$), mindfulness ($r = -0.22$, $r = -0.22$, $r = -0.22$, $p < .01$, $p < .01$, $p < .01$), and self-compassion ($r = -0.31$, $r = -0.31$, $r = -0.31$, $p < .01$, $p < .01$, $p < .01$), indicating that higher levels of self-efficacy, mindfulness, and self-compassion are associated with lower levels of math anxiety. Additionally, self-efficacy was positively correlated with mindfulness ($r = 0.27$, $r = 0.27$, $r = 0.27$, $p < .01$, $p < .01$, $p < .01$) and self-compassion ($r = 0.32$, $r = 0.32$, $r = 0.32$, $p < .01$, $p < .01$, $p < .01$), suggesting that these traits are interrelated. Mindfulness and self-compassion also demonstrated a strong positive correlation ($r = 0.47$, $r = 0.47$, $r = 0.47$, $p < .01$, $p < .01$, $p < .01$), indicating that individuals with higher mindfulness tend to have greater self-compassion.

Table 1

Correlations between Variables

Variable	Math Anxiety	Self-Efficacy	Mindfulness	Self-Compassion
Math Anxiety	1	-0.48**	-0.22**	-0.31**
Self-Efficacy		1	0.27**	0.32**

Variable	Math Anxiety	Self-Efficacy	Mindfulness	Self-Compassion
Mindfulness			1	0.47**
Self-Compassion				1

Note: * $p < .05$. ** $p < .01$. *** $p < .001$

Table 2

Multiple Regression results for Math Anxiety

Variable	B	LL	UL	SE B	B	R ²	ΔR^2
Constant	103.50	89.50	117.80	7.15		0.28	0.27
Self-efficacy	-0.82	-1.01	-0.63	0.11	-0.421		
Mindfulness	-0.03	-0.12	0.07	0.06	-0.039		
Self-compassion	-0.36	-0.68	-0.06	0.16	-0.138		

Note: CI=confidence interval; LL=lower limit; UL=upper limit., * $p < .05$. *** $p < .001$

A hierarchical multiple regression revealed that self-efficacy significantly predicted lower math anxiety, $B = -0.82$, $B = -0.82$, $B = -0.82$, $p < .001$, $p < .001$, $p < .001$, with higher self-efficacy associated with reduced anxiety. Self-compassion was another significant negative predictor, $B = -0.36$, $B = -0.36$, $B = -0.36$, $p < .05$, $p < .05$, $p < .05$. Mindfulness had minimal, non-significant effects. The model explained 28% of the variance in math anxiety, $R^2 = .28$, $R^2 = .28$, $R^2 = .28$, indicating self-efficacy as the strongest predictor.

Discussion

The present study aimed to examine the relationships between self-efficacy, mindfulness, and self-compassion as predictors of math anxiety among undergraduate mathematics students. The findings of this study are consistent with previous literature, supporting the significant role that self-efficacy and self-compassion play in mitigating math anxiety, while mindfulness had a weaker, non-significant impact. This section discusses these results in relation to the existing literature and offers implications for both future research and practical applications in educational settings.

The results revealed that self-efficacy was the strongest predictor of math anxiety, with a significant negative correlation ($r = -0.48$, $p < .01$, $r = -0.48$, $p < .01$, $r = -0.48$, $p < .01$) and a significant negative regression coefficient ($B = -0.82$, $p < .001$, $B = -0.82$, $p < .001$, $B = -0.82$, $p < .001$). This finding aligns with Bandura's (1997) social cognitive theory, which posits that self-efficacy—the belief in one's capability to successfully complete tasks—plays a crucial role in

regulating emotions and behavior in challenging situations. In the context of mathematics, students who possess high self-efficacy are more likely to approach difficult math tasks as challenges rather than threats, thus reducing anxiety.

Several studies have confirmed the relationship between self-efficacy and math anxiety. Usher and Pajares (2009) found that students with higher math self-efficacy reported lower levels of anxiety and performed better on math tasks. Similarly, Jain and Dowson (2009) demonstrated that self-efficacy is a strong predictor of both math performance and the avoidance of math-related tasks. The current study adds to this body of knowledge by showing that self-efficacy explains a significant portion of the variance in math anxiety ($R^2=.28$, $R^2 = .28$, $R^2=.28$) among undergraduate mathematics students.

One possible explanation for the strong relationship between self-efficacy and math anxiety is that students with higher self-efficacy are better equipped to manage the cognitive and emotional demands of math tasks. Bandura (1997) suggested that individuals with high self-efficacy are more likely to employ effective problem-solving strategies and remain resilient in the face of setbacks. In contrast, students with low self-efficacy may doubt their abilities, which increases the likelihood of experiencing math anxiety and avoiding math-related activities altogether (McMullan et al., 2012).

Self-compassion also emerged as a significant predictor of math anxiety in the current study ($B=-0.36$, $p<.05$ $B = -0.36$, $p < .05$ $B=-0.36$, $p<.05$), indicating that students who exhibit greater self-compassion tend to experience lower levels of math anxiety. This finding is consistent with previous research showing that self-compassion plays a protective role in mitigating anxiety and stress in academic contexts (Neff, 2003). Neff (2003) defines self-compassion as treating oneself with kindness and understanding in the face of failure or difficulty, which reduces self-criticism and promotes emotional resilience.

In the context of math anxiety, self-compassion may help students cope with the fear of failure by reframing their mistakes as opportunities for growth rather than as indicators of personal inadequacy (Akin, 2008). Hayes et al. (2016) found that self-compassion was negatively associated with general academic anxiety, and the current study extends this finding to math anxiety specifically. The significant negative correlation between self-compassion and math anxiety ($r=-0.31$, $p<.01$, $r = -0.31$, $p < .01$, $r=-0.31$, $p<.01$) suggests that fostering self-compassion in students could help them manage the stress associated with math-related tasks more effectively.

One potential mechanism underlying the relationship between self-compassion and math anxiety is emotional regulation. Allen and Leary (2010) proposed that self-compassion facilitates adaptive emotional regulation strategies, such as acceptance and cognitive reappraisal, which help individuals manage negative emotions like anxiety. Students who practice self-compassion are less likely to engage in rumination and self-blame, which are common cognitive patterns associated with anxiety (Neff & Germer, 2013). Thus, interventions that promote self-compassion could reduce math anxiety by helping students develop healthier emotional responses to challenging math tasks.

In contrast to self-efficacy and self-compassion, mindfulness did not significantly predict math anxiety in the current study ($B=-0.03$, $p>.05$, $B = -0.03$, $p > .05$, $B=-0.03$, $p>.05$). Although mindfulness was negatively correlated with math anxiety ($r=-0.22$, $p<.01$, $r = -0.22$, $p < .01$, $r=-0.22$, $p<.01$), its effect in the regression model was minimal. This finding contradicts some previous research suggesting that mindfulness can reduce anxiety by enhancing emotional regulation and attention control (Zeidan et al., 2010).

Brunyé et al. (2013) found that mindfulness-based interventions, such as mindful breathing exercises, reduced math anxiety and improved performance in students with high levels of anxiety. Similarly, LaGue et al. (2020) reported that mindfulness-based cognitive therapy significantly reduced math anxiety in high school students. However, the current study's findings suggest that mindfulness may not be as influential in predicting math anxiety as self-efficacy or self-compassion, at least among undergraduate mathematics students.

One possible explanation for the weaker impact of mindfulness on math anxiety is that the effects of mindfulness may depend on the specific mindfulness practices used and the individual's baseline level of anxiety. Shapiro et al. (2015) suggested that mindfulness may be more effective for individuals with high levels of trait anxiety or for those who engage in regular mindfulness practice over extended periods. In the current study, the mindfulness measure (FFMQ) assessed general mindfulness rather than specific mindfulness interventions, which may explain the lack of a significant effect.

The results of this study also highlight the interrelationships between self-efficacy, mindfulness, and self-compassion. Self-efficacy was positively correlated with both mindfulness ($r=0.27$, $p<.01$, $r = 0.27$, $p < .01$, $r=0.27$, $p<.01$) and self-compassion ($r=0.32$, $p<.01$, $r = 0.32$, $p < .01$, $r=0.32$, $p<.01$), suggesting that students who believe in their ability to succeed in math are also more likely

to exhibit higher levels of mindfulness and self-compassion. This finding aligns with Samuel and Warner's (2021) research, which showed that students with higher self-efficacy are better able to regulate their emotions and maintain focus, two key components of mindfulness.

The strong positive correlation between mindfulness and self-compassion ($r=0.47$, $p<.01$, $r = 0.47$, $p < .01$, $r=0.47$, $p<.01$) supports Neff's (2003) assertion that self-compassion and mindfulness are closely related constructs. Mindfulness involves non-judgmental awareness of the present moment, while self-compassion involves treating oneself with kindness in the face of difficulty. Together, these traits promote emotional resilience and reduce the likelihood of negative self-evaluation, which is a common precursor to anxiety (Allen & Leary, 2010).

The findings of this study have important implications for educational practice. Given that self-efficacy was the strongest predictor of math anxiety, educators should focus on enhancing students' math self-efficacy through targeted interventions. Strategies such as mastery experiences, positive feedback, and goal-setting can help boost students' confidence in their math abilities (Bandura, 1997). Additionally, incorporating self-compassion practices into the classroom, such as self-reflection and self-kindness exercises, may help students develop healthier responses to math-related challenges.

While mindfulness did not significantly predict math anxiety in the current study, mindfulness-based interventions may still benefit students with high levels of trait anxiety. Schools and universities could offer mindfulness training programs to help students develop attention control and emotional regulation skills, which are essential for managing academic stress (Shapiro et al., 2015).

Conclusion

In conclusion, this study provides valuable insights into the emotional and cognitive predictors of math anxiety among undergraduate mathematics students. The findings underscore the importance of self-efficacy and self-compassion in mitigating math anxiety, while mindfulness had a weaker effect. Educators and researchers should continue to explore strategies that enhance self-efficacy and self-compassion to help students manage math anxiety and succeed in their academic pursuits. There are several limitations to this study that should be considered. First, the cross-sectional design limits the ability to draw causal conclusions about the relationships between self-efficacy, mindfulness, self-compassion, and math anxiety. Future research should employ longitudinal

designs to assess how these traits influence math anxiety over time. Additionally, the sample was limited to undergraduate mathematics students in Lahore, which may restrict the generalizability of the findings to other populations or regions.

Future research should also explore the mechanisms through which self-efficacy, mindfulness, and self-compassion interact to influence math anxiety. For example, experimental studies could examine whether interventions that target both self-efficacy and self-compassion have a greater impact on reducing math anxiety compared to interventions that focus solely on one trait.

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