MINDFULNESS TO REDUCE MATH ANXIETY AND IMPROVE MATH PERFORMANCE

by

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APPROVAL SHEET

MINDFULNESS TO REDUCE MATH ANXIETY AND IMPROVE MATH PERFORMANCE

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Dedication

To my parents, my husband, and my children. Without their support, none of this could have been possible.

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Abstract

Math anxiety, the negative emotional response to math, is a common educational issue observed globally and across many grade levels. Additionally, it negatively impacts math performance and constrains long-term math achievement. Anxious ruminations strain mental resources and encourage avoidance behaviors such as procrastination. The prevalence and detrimental influence of math anxiety necessitate that educators mitigate math anxiety's negative impact in the classroom. Previous research suggests interventions emphasizing mindfulness, which is the intentional awareness of the present moment, can combat the ruminations of math anxiety. When complemented with interventions on growth mindset, which is the belief that intelligence can grow and change, educators can also enhance motivation and reduce avoidance behaviors. Mindfulness interventions have contributed to reducing math anxiety and improving math performance on isolated tests of math ability. However, research is lacking that thoroughly investigates the influence of a combined mindfulness and growth mindset intervention embedded in the classroom. The purpose of this mixed methods study is to evaluate the impact of a brief mindfulness and growth mindset intervention integrated into the classroom to benefit math anxiety, mindfulness, math performance, and student experiences in the course.

This quasi-experimental project with a control group implemented a mindfulness and growth mindset intervention in which professors of statistics courses for psychology students led their classes through a video-based mindful breathing exercise and recited five positive affirmations at the beginning of each class. Participants (N=99) were assessed for their levels of math anxiety and mindfulness at three points in the semester. Additionally, professors of the courses reported students' performance on homework, quizzes, and exams. Semi-structured interviews were conducted with some participants from the intervention and control group

(*N*=10). Repeated measures analyses of variance were utilized to compare changes across assessments between the intervention group and control group. Independent and paired-samples *t*-tests further explored the intervention's impact. Thematic analysis and comparison provided insight into the qualitative data. The intervention facilitated greater reductions in math anxiety and better maintenance of mindfulness levels compared to the control group. Additionally, the intervention benefited performance on moderate-stress assignments, such as quizzes, which subsequently benefited final grades. Thematic analysis further supports the intervention's positive impact on the classroom. This study contributes to educational resources that educators can implement into their classrooms to address the socioemotional and academic needs of their students. Future research should aim to replicate the effects and investigate generalizing the intervention to other anxiogenic situations.

Keywords: Mindfulness, Math anxiety, Growth mindset, Math performance, Classroom intervention, Mindfulness intervention

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Chapter 1: Introduction

Math anxiety, which is a phobia-like response to math, is prevalent across many countries and negatively impacts math achievement (Foley et al., 2017; Lau et al., 2022). The Program for International Student Assessment (PISA) evaluated the cross-cultural impact of math anxiety on achievement, reporting that a country's increase by one unit on their measurement for math anxiety correlated with a 29-point reduction in the country's math score (Foley et al., 2017). In the U.S., math anxiety has been observed across all grade levels, impacting elementary students all the way through college, with negative consequences distinct from test anxiety and general anxiety (Hart & Ganley, 2019; Ramirez et al., 2018). Math anxiety is especially relevant in college, as 25% of university students and as many as 80% of community college students experience deleterious impacts from math anxiety (Ramirez et al., 2018). This anxiety towards math not only reduces math performance but affects a student's enrollment in and engagement with math-related courses, such as algebra, physics, or statistics. Reduced performance and involvement in math leads to long-term consequences of constrained involvement in science, technology, engineering, and math (STEM) fields, which was emphasized in a recent meta-analysis (Barrosso et al., 2021). This detracts from the competitive edge of the U.S. within the global arena (Foley et al., 2017). Thus, it is evident that educational interventions targeting math anxiety are imperative to improve both psychological and academic outcomes.

While there are several ways theorized to reduce math anxiety, such as increasing math skills and reappraising physiological responses (see Ramirez et al., 2018 for a review), such interventions do not actually equip the students with the coping skills necessary to effectively respond to their anxiety. In contrast, interventions based on mindfulness and growth mindset have recently shown some promise (Samuel & Warner, 2021). Mindfulness is the ability to be

presently aware of oneself and one's situation (Brunye et al., 2013; Kabaat-Zinn, 2012) and growth mindset is one's belief that abilities relating to intelligence can continue to grow and mature over the lifespan (Yeager & Dweck, 2020). Mindfulness and growth mindset have independently demonstrated a negative relationship with math anxiety and a positive relationship with math performance. While mindfulness is frequently utilized in a counseling context or treatment program (Brown et al., 2013; Creswell, 2017), recent research has drawn attention to the valuable role of mindfulness interventions embedded in the classroom (i.e., Amutio et al., 2022; Andreu et al., 2021). However, few studies have evaluated the impact of a video-based mindfulness and growth mindset intervention integrated into the classroom to reduce math anxiety, enhance mindfulness, and improve math achievement within the course.

The aim of this project is to investigate the effectiveness of a combined mindfulness and growth mindset intervention to improve emotional regulation through increasing mindfulness and decreasing math anxiety, as well as assess whether this contributes to enhanced math performance. This project is innovative in expanding an intervention that has previously had success in reducing math anxiety (Samuel et al., 2022; Samuel & Warner, 2021) and contributing to better understanding of the intervention's impact on mindfulness and math performance. Demonstrating the effectiveness of this mindfulness and growth mindset intervention to not only reduce math anxiety but also to improve math achievement, can contribute to evidence-based, educational resources that teachers can easily utilize to address psychological aspects of the classroom to facilitate enhanced academic outcomes.

Chapter 2: Literature Review

Defining Math Anxiety

Early investigations into fearful emotional responses to mathematical stimuli described the condition as “number anxiety” (Dreger & Aiken, 1957, p. 344). This construct later became known as math anxiety, which is defined as the negative affective or physical response to math-related stimuli that impedes numerical tasks (Ramirez et al., 2018; Richardson & Suinn, 1972). This can include feelings of tension, stress, confusion, and dread (Ashcraft, 2002); physiological reactions, such as increased heart rate, nausea, cortisol levels, or galvanic skin response (Faust, 1992; Mattarella-Micke et al., 2011); and behavioral components, such as avoidant responses and impaired numerical ability (Korem et al., 2022; Richardson & Suinn, 1972). Some researchers have gone so far as to classify math anxiety as a phobia because of its impact on emotions, behaviors, and cognitions that parallels the American Psychiatric Association’s diagnostic criteria for a phobia (Faust, 1992). This phobia-like response to math is interrelated with one’s beliefs about their ability in math-related domains, which subsequently influences academic and career decisions, which was demonstrated by a cross-sectional study with 231 STEM and Social Science majors (Rozgonjuk et al., 2020). This highlights how anxious responses to math are associated with low self-esteem and low efficacy, as well as individual emotional dysregulation (Moustafa et al., 2021; Rozgonjuk et al., 2020).

This suggests that an individual’s math anxiety is related to their beliefs about themselves and their abilities to succeed (Finlayson, 2014). Some researchers argue that math anxiety develops as a learned response, via observing parents and teachers (Faust, 1992; Moustafa et al., 2021). Furthermore, the level of math anxiety in peers and the confidence of teachers further contributes to math anxiety and its impact on achievement (Finlayson, 2014; Lau et al., 2022).

However, math anxiety can also be influenced by genetic inheritance and predispositions towards anxious responses (Luttenberger et al., 2018). Clarifying the complex nature and impact of math anxiety is critical for educators and students to effectively respond to math anxiety (Finlayson, 2014).

Distinguishing From Other Anxieties

When discussing a domain-specific categorization, there is a question of whether math anxiety is distinct from other anxiety-related conditions, such as test anxiety and generalized anxiety, which was investigated by Hart and Ganley (2019) in 1000 U.S. adults. Their three measures for math anxiety each positively correlated with a general anxiety scale (r=.36 to .44, p<.001) and a test anxiety scale (r=.63 to .67, p<.001). While this supports a moderate to strong relationship between these kinds of anxieties, math anxiety is a distinct construct, as the three math anxiety measures were more strongly related with each other than with the other constructs (r=.83 to.87, p<.001). This is further supported by the review of Dowker et al. (2016), which notes math anxiety's moderate correlative strength with test and general anxiety, further supporting math anxiety as a separate construct whereas a stronger correlation would be more suggestive of overlapping constructs (Maxwell, 2001). In addition to research with adults, this distinction has also been supported in investigations with children, such as Ching (2017), who longitudinally investigated the relationship between math anxiety and ability in 246 Chinese students from second to third grade. Multiple regression analyses supported math anxiety as directly predicting mathematical performance, above any contributions of intelligence assessments, test anxiety, general anxiety, or working memory – which highlights the separation between math anxiety and other anxiety-related conditions (Ching, 2017). Understanding the

distinct nature of math anxiety, which is evident across the life span, is crucial for the condition to be effectively addressed.

Prevalence

Math anxiety, as a unique psychological phenomenon, is a widespread problem. Foley et al.'s (2017) review of math anxiety supported the negative relationship between math anxiety and performance on a global scale, reporting that 63 out of 64 of the countries assessed in the Program for International Student Assessment (PISA) correlated higher math anxiety with lower math ability, with moderate to large effects. They advocate for recognition of math anxiety as a global education issue with deleterious impacts across a variety of cultures (Foley et al., 2017). This is further supported by an extensive international investigation (N=1,175,515) which found an individual's math anxiety negatively impacted their math performance throughout the globe (Lau et al., 2022). Moreover, math anxiety is prevalent across many grade levels. Specifically, in the U.S., it is estimated that math anxiety impacts 11% of school-age children, peaks at 33% of adolescents, and remains influential in college, affecting 25% of college students, with community college students especially at risk (Korem et al., 2022; Ramirez et al., 2018).

Impact of Math Anxiety

In addition to being a worldwide education concern, math anxiety negatively impacts students on an individual level. While a certain amount of stress can be beneficial for performance (e.g., Henderson et al., 2012), debilitating levels of anxiety can disrupt performance and contribute to lower academic achievement, which reflects a "choking under pressure" (Beilock, 2008, p. 339). Math anxiety has consistently demonstrated a negative relationship with math performance, with correlations ranging in strength from low to moderate (Ashkenazi & Danan, 2017; Barroso et al., 2021; Dowker et al., 2016). As Ching (2017) demonstrated, math

anxiety's negative relationship with math achievement stands regardless of intelligence measures and working memory ability. In one study with 58 college students, higher math anxiety correlated with lower scores for number line knowledge (r=-.28, p<.05) and reduced efficiency for math calculations (r=-.54, p<.001; Ashkenazi & Danan, 2017). This is corroborated by an investigation with 47 preservice teachers, in which math anxiety had a statistically significant (p<.05) negative relationship with working memory (r=-.33), confidence in math (r=-.89), math accuracy (r=-.70), and overall GPA (r=-.33; Novak & Tassell, 2017). Several recent meta-analyses further support the negative correlation between math anxiety and math performance (Caviola et al., 2021; Finell et al., 2021; Namkung et al., 2019). This inverse relationship holds whether math anxiety is assessed via an explicit self-report measure (r=-.27, p<.05) or via implicit association tasks (r=-.17, p<.05), as demonstrated in a sample of 175 college students (Westfall et al., 2021).

Some research has suggested that women potentially have higher math anxiety than men which may subsequently contribute to gender differences in math performance (Luttenberger et al., 2018; Rozgonjuk et al., 2021). For example, Hart and Ganley's (2019) study on the presence of math anxiety in the U.S. (N=1000) observed statistically significantly higher math anxiety in women than men, with medium effect sizes. Women also had lower math fluency and were less likely to be in a STEM career (Hart & Ganley, 2019). This is congruent with research by Beilock (2008) and Maloney et al. (2013) that suggests stereotype threat and math anxiety function through similar mechanisms to contribute to underperforming in math-related scenarios. Anxiety, high pressure-situations, and stereotypes can contribute to reducing one's performance on cognitively challenging tasks (Novak & Tassell, 2017; Maloney et al., 2014). However, a recent scoping review noted there is variability within the literature on anxiety and gender differences

and gender's impact on the development of math anxiety may be influenced by sex-role socialization within a culture (Khasawneh et al., 2021). When addressing the relationship between math anxiety and math performance, there is also considerable variability on the direction of causality within the relationship. Does math anxiety impair effective math performance, or conversely, does poor math ability contribute to feeling anxious about math? How math anxiety influences math performance is not clear.

Mechanisms Behind the Impact

Processing Efficiency Theory

A possible theory for anxiety's impact on ability is the Processing Efficiency Theory (PET; Eysenck and Calvo, 1992). This theory suggests anxiety impairs performance via influence on the limited capacity processing system, working memory. Proposed by Baddeley and Hitch (1974), working memory is a tripartite model composed of the central executive, phonological loop, and visuospatial sketchpad. The PET argues that the central executive is impacted by anxiety such that anxious thinking and negative rumination diverts attentional resources from the task at hand as the individual instead focuses on their anxiety (Eysenck & Calvo, 1992; Eysenck & Derakshan, 2011). This interaction is highlighted in Bellinger et al.'s (2015) study with 112 undergraduate students, in which state anxiety negatively related to performance, especially for tasks that heavily relied on working memory ability.

While originally theorized regarding general anxiety, researchers subsequently applied the PET to math anxiety (Ashcraft & Faust, 1994; Ashcraft & Kirk, 2001, Hopko et al., 1998). For math-related stimuli, high levels of math anxiety utilize working memory for emotional processing, limiting the mental workspace that is available to solve the math tasks (Ashcraft & Kirk, 2001). This is bolstered by the finding that math anxiety negatively relates to both math

performance and computation-based working memory assessments, suggesting that when a stimulus is numerically based, individuals underperform on working memory assessments compared to non-numerical context (*N*=61; Shi & Liu, 2016). This differential processing is further supported by physiological investigations, such as Young et al. (2012), whose fMRI study observed increased connectivity between the amygdala and cortical regions in students with high math anxiety, supporting the diversion of cognitive resources to emotional processing.

Cognitive Deficit Theory

While many researchers have demonstrated the deleterious impact of math anxiety on math performance, others have highlighted the impact of lacking basic math ability as facilitating the development of math anxiety in the first place. This cognitive deficit theory hypothesizes that lack of math skills contributes to math anxiety (Foley et al., 2017; Georges et al., 2016; Korem et al., 2022). For example, Georges et al.'s (2016) behavioral investigation into spatial and numerical representations demonstrated that those with higher math anxiety had deficits in basic number processing and spatial skills. While higher math anxiety was associated with reduced performance and working memory, Korem et al.'s (2022) network analysis in 116 undergraduate students emphasized that math anxiety and working memory have distinct contributions to math anxiety. This was supported by Skagerland et al. (2019), who addressed math anxiety and performance in 170 Swedish adults. While the math anxiety-performance relationship was mediated by working memory, it was also mediated by number processing ability. Physiological findings using electroencephalogram also support this theory, as high math anxiety corresponded to reduced activity in areas of the brain that contribute to numerical processing (Klados et al., 2015). Cognitive interference and cognitive deficits may play a role in math anxiety and ability (Skagerland et al., 2019).

Long-Term Outcomes

Considering mixed opinions on the mechanism behind math anxiety's impact on math achievement, it is likely that both theories are involved in the complex relationship, contributing to long-term impact (Ramirez et al., 2018). Math anxiety impacts math achievement via cognitive impairment of working memory, evidenced by working memory ability mediating the relationship between math anxiety and math performance (e.g., Ashkenazi and Danan, 2017; Justicio-Galiano et al., 2017; Szczygiel, 2021). In addition to influencing short-term performance in math-related situations, math anxiety also negatively impacts behaviors relating to learning, such as studying techniques and procrastination (Luttenberger et al., 2018). Thus, a developmental perspective of math anxiety is beneficial. The effects of avoidance behaviors, disengagement in coursework, and misallocation of cognitive resources accumulate and constrain long-term math involvement, which contributes to the direct impact that math anxiety has on math performance in math anxious adults in addition to the indirect relationship via working memory (Korem et al., 2022; Pizzie et al., 2020; Szczygiel, 2021).

This highlights how math anxiety not only influences cognitive abilities, but observable behaviors as well, contributing to avoidance responses such as seen in phobias or other anxiety conditions. While a discussion of whether the chicken or the egg comes first is beyond the scope of this paper, it is evident that math anxiety and performance have a cyclical relationship, such that decreasing levels of competence with math are associated with increasing levels of anxiety, which contribute to reduced development and execution of math-related skills, which subsequently affects academic and vocational decisions (Luttenberger et al., 2018; Ramirez et al., 2018).

Reducing Math Anxiety

Having established the prevalence and pervasive impact of math anxiety, it raises the question of what can be done about it. A recent review of math anxiety noted two primary categories for interventions to alleviate anxiety surrounding mathematics: a cognitively-focused approach and a social-psychological approach (Ramirez et al., 2018). These approaches reflect underlying assumptions regarding the nature of math anxiety and its relationship with math ability.

Cognitive Approach

Specifically, the cognitive approach points to educational interventions geared towards enhancing students' abilities with math (Supekar et al., 2015). As skills increase, the exposure to math-related stimuli can function as an exposure therapy, enabling desensitization, analogous to the treatment of a phobia (Faust, 1992; Ramirez et al., 2018). The cognitive approach is demonstrated in Supekar et al.'s (2015) study, as 46 third-grade students participated in an 8-week cognitive tutoring program structured to enhance their math ability. Students with high math anxiety showed a significant reduction in math anxiety following the intervention. Their program was associated with reducing overactivity in anxiety-related circuits, such as the amygdala. Moreover, the degree of impact on these emotional circuits correlated with the extent of reduction in math anxiety experienced by the students (Supekar et al., 2015).

Psychosocial Approach

In contrast, interventions derived from emphasis on the psychological impact of math anxiety highlight the importance of how one appraises the math-related situation (Ramirez et al., 2018). For example, encouragement to interpret physical arousal during exams as beneficial for performance was associated with reduced math evaluation anxiety and improved performance,

with a medium effect size in community college students compared with a control group (*N*=93; Jamieson et al., 2016). However, this intervention only improved math execution anxiety, and not math learning anxiety. Within the context of a classroom, addressing psychosocial aspects could reduce anxiety, improve learning, and enhance performance for math-related tasks (Jamieson et al., 2016).

Limitations of Prior Interventions

An understanding of the complex nature of math anxiety is critical to mitigate anxiety and its deleterious impacts. While increasing skills is accompanied with decreasing anxiety, it does not answer the question of how to facilitate learning and performance for students in the classroom that are actively dealing with math anxiety and struggling to develop skills because of it. Moreover, such an intensive tutoring program that Supekar et al. (2015) implemented cannot be easily adapted to meet the needs of math anxious students in the classroom. While psychosocial interventions such as cognitive reappraisal (Jamieson et al., 2016) have also had success in mitigating the effects of math anxiety, there is a need for interventions to address the maladaptive emotional responding in math anxiety and equip students with better anxiety-regulation abilities which could subsequently improve math learning and math performance. This derives from an understanding of the complex mechanisms behind math anxiety as interventions need to address the negative ruminations that distract from the task at hand as well as the avoidance behaviors relating to math classes and coursework.

Mindfulness

Considering the impact of math anxiety on engagement with and execution for math-related tasks, it is critical for educational interventions to address the psychological aspects influencing learning, and one possible method to do so is based around mindfulness (Samuel &

Warner, 2021). Mindfulness, a non-judgmental awareness of the present moment, has its roots in Buddhist philosophy, however recent psychological research has drawn attention to the benefits of mindfulness (Creswell, 2017; Kabat-Zinn, 2012). Mindfulness interventions are geared towards helping people quiet their thoughts and become attentive to their present reality (Brunye et al., 2013). With this emphasis on quieting thoughts and reducing negative ruminations, it is fitting for mindfulness interventions to address the strained working memory capacity due to math anxiety (Samuel et al., 2022). While the influence of mindfulness in formal psychological research can be traced to Kabat-Zinn's Mindfulness-Based Stress Reduction (MBSR) program in the 1970s (Creswell, 2017; Trammel, 2017), several different ways to facilitate mindfulness have permeated the mental health field, which vary in style and intensity. Mindfulness interventions have included breathing exercises (Samuel & Warner, 2021), meditation (Bultas et al., 2021), yoga (Lampe & Müller-Hilke, 2021), and body-scanning method (Vorontsova-Wenger et al., 2021). In addition to being minimal risk, mindfulness-based designs can be easily modified to fit within curriculum, making it an optimal addition to integrate within the classroom (Creswell, 2017; LaGue et al., 2019; National Institute of Health, 2016).

Correlates

Before implementing mindfulness-based interventions, it is necessary to understand mindfulness itself and how it relates to math anxiety and performance. Mindfulness entails deliberate cultivation of attentiveness to the present moment and responding in a manner that is not reactive or judgmental (Kabat-Zinn, 2015). Correlational research has implicated mindfulness as negatively related to perceived stress (Lampe & Müller-Hilke, 2021) and anxiety (Bellinger et al., 2015; Hofmann & Gomez, 2017), as well as math anxiety specifically (Tassell et al., 2020). In a mixed sample (N=81) of adults and university students, dispositional

mindfulness was negatively correlated with math anxiety (r=-.245, p<.05; David et al., 2021). In a predominantly female sample of undergraduate students, Weed et al. (2021) corroborated the negative relationship between mindfulness and math anxiety (r=-.29, p<.001, N=192). Similarly, a review of math anxiety's impact on college students alluded to the benefits of enhanced self-awareness to reduce math anxiety and improve performance (Khasawneh et al., 2021). Past correlational research provides the theoretical basis for the application of enhancing mindfulness to reduce math anxiety.

Mindfulness also can potentially ameliorate the negative impacts of math anxiety on cognitive functioning and performance. Working memory ability positively correlated with level of mindfulness, across both high-pressure and low-pressure situations (Li et al., 2021). Li et al. argue that mindfulness can be protective against stress interfering with working memory ability, which can facilitate higher levels of academic performance. Moreover, mindfulness is positively related to academic performance, demonstrated by Miralles-Armenteros et al. (2019) in a sample of 210 university students and its relationship is mediated through compassion and engagement. Mindfulness also predicts math grade as mindful students show better levels of achievement in math classes. When including prior math ability and the level of mindfulness, their model explained 12% of the variance in math grade (Weed et al., 2021). This was supported by Lu et al. (2017), as mindfulness assessed via the Mindful Attention Awareness Scale (MAAS) was related to math grade with a medium effect, with the overall model predicting 11% of the variance in math performance. Stronger predictive ability was noted by Bellinger et al. (2015), who found that mindfulness - also measured with the MAAS - had a direct and indirect relationship via state anxiety with performance on math exams, predicting 28.7% of the variation in exam scores. This further demonstrates the complex relationship between mindfulness, anxiety, and academics.

Impact of Mindfulness Interventions

Psychological

Building off the theoretical foundations of correlational investigations, mindfulness-based interventions have been applied to anxiety as well as math anxiety specifically and research has supported the real-world benefits of mindfulness. A review of mindfulness-based programs supported its mitigation of depression and anxiety, compared to both passive and active control groups (Hofmann & Gomez, 2017). This is supported by a review of 57 studies on mindful meditations with college students which emphasized mindfulness meditations as reducing participant stress and anxiety (Bamber & Schneider, 2016). However, these interventions are often time-intensive, which can be a barrier to successful implementation (Bultas et al., 2021). It is worth noting that such interventions do not need to be time-intensive to have an impact, which is demonstrated by a two-week training in breathing exercises which reduced test anxiety in 10th-grade students, with a medium effect (Contreras, 2020). Similarly, in a study with 49 nursing students, a 5-minute mindfulness meditation reduced anxiety prior to taking an exam compared to a control group; however, they did not assess whether this affective impact subsequently influenced performance on the exam (Bultas et al., 2021). In addition to anxiety, the impact on math anxiety has been investigated as well, such as a multiple-baseline, single-case study with three adolescents which demonstrated 12 sessions of mindfulness-based cognitive therapy across 6 weeks was effective in reducing their level of math anxiety (LaGue et al., 2019). A brief intervention, consisting of 15 minutes of mindful breathing, also demonstrated efficacy in reducing math anxiety, with medium effect (Brunye et al., 2013).

In addition to anxiolytic benefits of mindfulness-based designs, there are benefits for increases in mindfulness. This is supported by a review of randomized controlled trials (RCTs)

investigating MBSR programs, which emphasized physical and mental health benefits (Creswell, 2017). However, a criticism raised by Creswell (2017) is the lack of studies that evaluate the extent to which an intervention centered around mindfulness actually influences the participants' level of mindfulness. For studies that have addressed this, there are small to large effects for increasing the mindfulness of the participants, varying due to the differential intensity of the interventions (Lampe & Müller-Hilke, 2021; Mahmood et al., 2016; Vorontsova-Wenger et al., 2021).

Cognitive

The benefit of mindfulness interventions to quiet the mind and improve efficiency in working memory is demonstrated by the RCT of Quach et al. (2016). Their study utilized 198 adolescents investigating the impact of eight 45-minute sessions of mindful meditations on working memory capacity. The mindfulness intervention enhanced cognitive function above the impact of an active control group doing hatha yoga and a passive control group, with a large effect (η^2=.24; Quach et al., 2016). Mindfulness training also positively influenced working memory on a math-related working memory assessment in a sample of military personnel, compared with a military control group; overall degree of practice in the mindfulness training correlated to degree of impact on working memory capacity (Jha et al., 2010).

This is corroborated by a meta-analysis of 29 studies including RCTs and quasi-experimental designs, which demonstrated group-based mindfulness programs positively impact executive functioning, such as inhibition, working memory, and verbal fluency (Millett et al., 2021).The impact of mindfulness training on attentional abilities and working memory is theorized to subsequently enhance performance and mental health outcomes (Jha et al., 2019). Their research highlights the ability of mindfulness to reduce negative ruminations and enhance

working memory, providing the foundation for the translational value of mindfulness in the classroom.

Academic

In addition to psychological and executive functioning benefits, research suggests mindfulness carries tangible impacts in improving academic performance. In Vorontsova-Wenger et al.'s (2021) research, 50 undergraduate students practiced body scanning for 30 minutes each day for 8 weeks, which contributed to decreases in anxiety and depression symptomology (η^2=.741) as well as improved self-reported academic performance (η^2=.731) compared to controls. A different 8-week MBSR intervention improved academic performance in adolescents, with a large effect, predicting over 70% of the variance in performance (N=300; Anila & Dhanalakshmi, 2016). A more moderate effect was observed by Sampl et al. (2017), in which a 10-week mindfulness training program with 109 undergraduate students contributed to improved academic performance. Furthermore, they emphasize the cumulative benefits of mindfulness training as contributing to reduced test anxiety in the experimental group compared with controls (Sampl et al., 2017). Other researchers have argued that mindfulness can improve math performance via mitigating the negative impact of stereotype threat (e.g. Weger et al., 2012), which is theorized to function in a similar manner as math anxiety (Maloney et al., 2013). While these interventions can be intensive and time-consuming, there is evidence that even brief interventions can have an impact, such as the 15-minute focused breathing exercise utilized by Brunye et al. (2013). In addition to reducing math anxiety, mindfulness also contributed to improving math performance for undergraduate students with high math anxiety in a lab context (Brunye et al., 2013). The integration of mindfulness does not need to be time-intensive to have a significant impact on anxiety, academics, and the execution of math-related skills.

Classroom-Based Mindfulness

While previous research has evaluated the impact of mindfulness to reduce math anxiety and improve performance on math tests in the context of the lab, recent research has integrated it within educational contexts (e.g., Samuel & Warner, 2021). Schonert-Reichl et al. (2015) utilized twelve 45-minute socioemotional learning lessons centered around mindfulness, once a week for 99 fourth- and fifth-grade students, which contributed to better cognitive control, reduced stress, enhanced social interaction, and improved math ability, with small to moderate effect sizes. A briefer embedded design was utilized by Mapel (2012), which integrated 6-minute guided meditation exercises in the beginning of class for adult learners across 28 lectures. This mixed methods study demonstrated that students generally perceived the integration of mindfulness as beneficial, both emotionally and academically (Mapel, 2012). Moreover, utilizing mindful meditation to start the class time enhanced students' focus and engagement, which can contribute to better learning and performance.

In a study with social work undergraduate students, integration of 10-15 minutes of mindfulness techniques at the beginning of class contributed to perceived benefits, although the students were challenged in translating the benefits outside of the classroom (Tufford et al., 2019). The qualitative feedback to the intervention criticized the length of time for the exercise, which detracted from class time. Other studies have utilized brief mindfulness programs, such as Miller et al. (2019) who utilized a 3-minute breathing exercise to start the class with 88 undergraduate psychology students enrolled in psychology courses. The intervention group had reduced distractibility and increased positive emotionality; however, there was not a statistically significant difference in mindfulness compared to the control group (Miller et al., 2019). Research which embeds mindfulness-based principles in the classroom highlights the positive

impacts for individual students and the classroom as a whole; however, it also draws attention to the need for interventions to be easily utilizable by faculty and not consume too much class time.

Experiences with Mindfulness

When considering the impact of interventions from a quantitative perspective, there can be attitudes and barriers that are not uncovered by scales. This deficit can be supplemented through qualitative investigation, which enables fluid data collection, rich detail, and deeper understanding (Creswell & Poth, 2018). Previous research has investigated how individuals engage with mindfulness interventions, including adolescents, (LaGue et al., 2019; Monshat et al., 2013), college students (Bamber & Schneider, 2020; Mapel, 2012; Samuel & Warner, 2021), and educators (Kenwright et al., 2021; Mackenzie et al., 2020), which has contributed to in-depth understanding of how participants perceive and experience mindfulness training, especially relating to stress management, emotion regulation, and translational application of mindful ways of being (Kabat-Zinn, 2005; Monshat et al., 2013; Tufford et al., 2019).

From the perception of students, benefits of mindfulness include enhanced engagement in academic material, improved relationships, and higher levels of prosocial behavior, which can enhance the overall classroom environment (Crowther et al., 2020; Mapel, 2012; Vestad & Tharaldsen, 2021). From the perspective of teachers, mindfulness interventions impacted academic resilience and coping as well as social skills of the students, positively influencing the educational context (Kenwright et al., 2021). Both students and instructors reported perceiving mindfulness in the classroom as a positive element of the class routine and a refreshing way to begin the class (Samuel et al., 2022; Samuel & Warner, 2021). Moreover, several qualitative investigations also emphasize the importance of teacher involvement in facilitating the intervention (Bamber & Schneider, 2020; Samuel & Warner, 2021). Thus, the qualitative inquiry

is congruent with quantitative findings, emphasizing the benefits of integrated mindfulness and the prioritization of student wellbeing and socioemotional health for improving academic environment, attitudes, and outcomes (Crowther et al., 2020). While there are barriers to successful mindfulness implementation, college students generally perceive mindfulness as beneficial when integrated into the classroom (Bamber & Schneider, 2020; Mapel, 2012). However, many of these studies lack a control group, which could further demonstrate the benefit of the intervention (see Crowther et al., 2020 for a review).

Video-Based Mindfulness

Given the reported impact of teachers and faculty on facilitating mindfulness interventions embedded in the classroom, it raises a question of whether a mindfulness intervention delivered in a video-based format would also have a positive impact. The ability of mindfulness programs to be delivered in an online format is demonstrated by Ahmad et al. (2020). In their RCT, 113 college students were assigned to 8 weeks of one of two kinds of mindfulness training: interactive (which involved mindfulness videos, peer discussions, and live videoconferencing) and video-based (which involved access to 12 mindfulness training videos); compared to controls and mindfulness-based cognitive behavioral therapy (CBT) in a group format. They observed reduced depression, anxiety, and perceived stress, with moderate effect sizes, as well as increased mindfulness and quality of life, with small to moderate effects, for both kinds of mindfulness training compared to the control group (Ahmad et al., 2020). Results for the CBT mindfulness were reported by Morr et al. (2020), which further support reduced depression and anxiety (Cohen's d = .69 to .74), and increased mindfulness (d=.47*)* for the mindfulness CBT and web-based mindfulness programs in comparison with the control group.

Their research highlights how video and web-based formats for mindfulness interventions can still impact the psychological symptoms and mindfulness of the participants.

Despite being video-based, the 8-week program of Ahmad et al. (2020) and Morr et al. (2020) was still intensive and time-consuming. In contrast, Amutio et al. (2022) evaluated the impact of a 13-minute mindfulness training in a sample of 125 university students. Using the training at the beginning of class was found to positively impact mindfulness, psychological well-being, classroom climate, and perceived stress compared to wait-list controls (Amutio et al., 2022). Similarly, a 5-minute mindfulness meditation video was used by Mahmood et al. (2016) to investigate its impact on state mindfulness. In two studies with 90 and 61 participants, the intervention group had enhanced state mindfulness compared to the control group, with effect sizes that were moderate in the first study ($\eta^2 = .10$) and large in the second study ($\eta^2 = .16$; Mahmood et al., 2016). State mindfulness is considered a transient experience of being mindful in contrast with consistent mindfulness as an aspect of one's character, which is known as trait mindfulness (Bamber & Schneider, 2016). Thus, while the brief intervention only elevated temporary mindfulness, consistent boosts in state mindfulness are hypothesized to contribute to the development of trait mindfulness, which supports the concept of cumulative benefits of repeated mindfulness exposure, as emphasized by Sampl et al. (2017). Consistent mindfulness experiences, despite being brief, can contribute to long-term benefits, especially relating to stress and anxiety (Bamber & Schneider, 2016).

The correlational, quasi-experimental, and experimental research designs suggest that mindfulness interventions can be efficacious in reducing anxiety, redirecting focus toward the present and improving academic – and specifically mathematic – performance. The flexibility and impact of mindfulness principles make it an optimal addition to a math classroom to mitigate

the overwhelming ruminations and negative impact of math anxiety. However, some mindfulness-based programs rely extensively on faculty, such as additional training prior to utilizing an intervention (e.g., Samuel et al., 2022); thus, it is necessary to consider adapting mindfulness principles to create educational resources which can be easily implemented by teachers. While there is empirical support for the impact of mindfulness programs to be maintained in video-based formats, there is limited research using a video-based mindfulness intervention embedded in the classroom to impact not only the mindfulness of the students, but their math anxiety as well. There is also a need to investigate whether the affective results of the intervention would translate to improved performance in the context of a math-related course, such as statistics. While mindfulness has unique potential to mitigate negative ruminations with math anxiety, the avoidance behaviors relating to classes and coursework must also be addressed.

Growth Mindset

Another style of intervention that has recently increased in usage are those built off principles of growth mindset, which may serve as an ideal complement to mindfulness. Growth mindset is the mental disposition that one's capabilities can continue to grow and develop throughout the lifespan, especially abilities relating to intellect or intelligence (Dweck, 2006; Dweck et al., 1995). In contrast, a fixed mindset suggests that one's intelligence or abilities are set, and will not improve (Yeager & Dweck, 2020). Some studies have suggested that one's mindset or beliefs about their abilities can contribute to confidence and motivation (Samuel & Warner, 2021) as well as predict student outcomes and performance (Blackwell et al., 2007; Yeager & Dweck, 2020).

According to a review of growth mindset, some interventions structured around encouraging growth mindset have had success in improving academic outcomes although there is variation in the literature (Yeager & Dweck, 2020). Porter et al.'s (2022) study with 1,996 middle school students and 50 teachers demonstrated the academic benefit of the faculty implementing a video-based growth mindset intervention, with grade increases of 2.4 percentage points. Specifically, students who were at risk for failing experienced the greatest impact of the intervention, with increases of 2.81 percentage points in grades (Porter et al., 2022). Thus, principles of growth mindset can be embedded in the classroom and improve academic achievement. However, their intervention, which utilized 30-to-60-minute videos during class-time across 10 weeks, may be less accessible to teachers who feel the time constraints in the classroom (Porter et al., 2022).

Relationship to Mindfulness

Growth mindset is theorized to relate to mindfulness. In studying the relationship between job-related stress and happiness in clinical nurses, Park and Choi (2021) observed a strong correlation between measures of mindfulness and growth mindset (r=.58, p<.001). One mixed methods study with 20 preservice teachers also observed an interrelationship between mindfulness, self-efficacy, and mindset; moreover, these variables shaped their pedagogical practices (Tassell et al., 2020). Another quasi-experimental study (N=450) observed that an intervention based on mindfulness helped to enhance self-concept, self-esteem, and growth mindset in undergraduate students compared to a control group (Saraff et al., 2020).

Impact of Combined Interventions

Despite the success and complementarity of mindfulness and growth mindset, only a few recent studies have utilized them in conjunction. In one qualitative study with secondary school

students, they evaluated an educational intervention centered on socioemotional skills, regarding relationships, emotion-management, mindfulness, problem-solving, and growth-mindset across 20 weekly sessions of 60 minutes apiece, embedded in school hours (Vestad & Tharaldsen, 2021). The thematic analysis suggests that students generally perceived mindfulness, growth mindset, and problem-solving as beneficial for managing academic stress. Mindfulness and problem-solving skills were experienced as supporting preparation and engagement in academic assignments whereas growth mindset facilitated motivation to learn (Vestad & Tharaldsen, 2021). This time-intensive intervention highlights the complementary application of mindfulness and growth mindset to address academic engagement and student motivation.

The specific application of classroom-integrated mindfulness and growth mindset interventions to address math anxiety is still emerging. Samuel et al. (2022) and Samuel and Warner (2021) trained faculty with mindfulness and growth mindset principles, enabling faculty to lead one minute of breathing exercises and five positive affirmations at the beginning of each class period. Students in math-related courses that received the intervention integrated into their class period had a significant decrease in math anxiety with moderate effect sizes, compared to a control group which received usual classroom instruction.

While this has demonstrated that brief mindfulness and growth mindset interventions can have an impact on math anxiety, they did not evaluate the extent to which the intervention actually influenced the mindfulness or growth mindset of the participants. Moreover, there is little research on whether the emotional impact translates to improved outcomes within the class. Only Samuel et al. (2022) investigated the changes in math anxiety and math performance. Despite an integrated mindfulness intervention successfully reducing math anxiety compared to a control group, there was not a statistically significant difference between the intervention group

and a control group on the final exam (Samuel et al., 2022). However, other grades were not addressed and their study did not control for prior math ability. Thus, it is evident that more research is needed as to the academic value of this integrated intervention.

The research of Porter et al. (2022), Vestad and Tharaldsen (2021), and Samuel and Warner (2021) highlights how growth mindset and mindfulness interventions can be complementary, helping students to manage stress, engage in coursework, and be motivated to learn. This demonstrates how the combined utilization of mindfulness and growth mindset is uniquely suited to address the complex nature of math anxiety, as the mindfulness component can facilitate present moment engagement and quiet the negative ruminations that are central to math anxiety (e.g., Ashcraft & Faust, 1994; Ashkenazi & Danan, 2017), while growth mindset can contribute to motivation and reduce the avoidance behaviors that are also present in math anxiety (e.g., Foley et al., 2017).

The Current Study

Gaps in the Literature

Due to the widespread impact of math anxiety and its immediate and long-term consequences on math performance, there is a critical need for educational interventions to mitigate math anxiety to improve academic outcomes. Previous research has highlighted the psychological, cognitive, and anxiolytic benefits of mindfulness- and growth mindset-based interventions. Despite demonstrated benefits of embedding such programs in the classroom, there are no known studies that evaluate the cumulative effects of a brief video-based mindfulness and growth mindset intervention embedded in the classroom to not only reduce math anxiety and enhance mindfulness, but also to improve performance in a math-related course.

Rationale and Innovation

The global prevalence and deleterious consequences of math anxiety necessitate enabling educators to equip students with the tools to cope with math anxiety. Higher math anxiety is associated with straining the working memory capacity, thus leaving less cognitive resources to devote to the task at hand. As mindfulness interventions attempt to calm the mind and provide skills for effectively regulating emotions and anxiety, there is support for its utilization to reduce math anxiety and improve math performance. The purpose of this mixed methods study is to evaluate the impact of a standardized version of Samuel and Warner's (2021) intervention embedded into a classroom and its ability to reduce math anxiety, enhance mindfulness, and improve math performance. This intervention will utilize a one-minute video of breathing exercises (Headspace, 2018) as well as instructor-led recitation of five positive affirmations, as utilized by Samuel and Warner (2021) and Samuel et al. (2022). While it is following a comparable design as Samuel and Warner (2021), this research is novel in using a video-based format for the breathing exercises rather than relying on instructor-led breathing exercises.

In addition to quantitative insight, this study will include qualitative interviews at the beginning and end of the semester. As very little qualitative work utilizes a pretest-posttest design to address changes in attitudes over the course of semester, this will enable more thorough evaluation of the experiential impact of a mindfulness and growth mindset intervention. This research is innovative because it ties together the strands of research around mindfulness, investigating the affective impact, academic benefit, and perceived experiences. Demonstrating the efficacy of a standardized mindfulness and growth mindset intervention is critical as it could become an accessible resource for educators, facilitating emotional regulation, academic engagement, and creating an optimal environment for learning.

Specific Aims

Aim 1: Analyze the relationship between mindfulness, math anxiety, and math performance for psychology undergraduate students.

Hypothesis 1a: Mindfulness will be negatively related to math anxiety

Hypothesis 1b: Mindfulness will be positively related to math performance

Hypothesis 1c: Math anxiety and moderate to high-stakes math performance, such as exams and quizzes, will be inversely related

Hypothesis 1d: Math anxiety and low-stakes math performance, such as homework, will not be correlated

Aim 2: Investigate the impact of a mindfulness and growth mindset classroom intervention on emotional components of math anxiety, assessed through the Revised Math Anxiety Rating Scale, and mindfulness, assessed via the Mindful Attentional Awareness Scale.

Hypothesis 2a: The intervention group will have enhanced mindfulness compared to the control group.

Hypothesis 2b: The intervention group will have reduced math anxiety compared to the control group.

Aim 3: Evaluate the impact of the intervention on math performance (assessed via teacher-reported grades on homework, exams, and quizzes).

Hypothesis 3a: The intervention group will not have significant differences in math performance as assessed via homework because of the differential stakes of the situation.

Hypothesis 3b: The intervention group will have statistically significantly enhanced math performance as assessed via quizzes.

Hypothesis 3c: The intervention group will have statistically significantly enhanced math performance as assessed via exams.

Aim 4: Explore the impact of the intervention on the experiences of students in the classroom.

Chapter 3: Methodology

This project investigated how mindfulness and growth mindset could be integrated into a college statistics classroom for psychology students to improve student math anxiety, classroom experience, and academic outcomes. This study was an embedded, mixed methods, quasi-experimental, repeated measures design. As an embedded design, this consisted of primarily quantitative investigation that was supplemented by qualitative inquiry.

Participants

Participants were recruited from four sections of two statistics courses for psychology students at a large Christian university. The initial sample had 99 undergraduate psychology students. The sample was predominantly female (76.8%), White (82.8%) and between the ages of 18-20 years old (70.7%). Four participants did not fill out their ID, which prevented linking responses with subsequent surveys. Twelve participants did not complete the second assessment and an additional eight participants did not complete the last assessment, which resulted in a final sample of 75 participants who completed all three surveys. Three participants who missed the second assessment did complete the final assessment, enabling a sample of 78 for comparisons between the first and final assessment. To be eligible to participate, subjects had to be 1) 18 years of age or older; 2) current students at Liberty University; and 3) enrolled in a residential section of either Statistics for Social Sciences (PSYC 354) or Statistics in Psychology (PSYC 355). Students who participated in the quantitative portion of the research were eligible for three Psychology activity credits and a raffle entry for one of five $15 Visa© gift cards. Students who

participated in an additional qualitative portion were entered into a raffle for one of ten $15 Visa© gift cards.

Instrumentation

Mindfulness and Growth Mindset Intervention

The independent variable in this study was group status in the intervention group or the control group. Randomization took place at the level of classroom. PSYC 354 had two sections, which were randomly assigned to either receive the intervention or function as a control. The PSYC 355 course also had two sections, which were similarly randomly assigned to intervention or control. The intervention, which was integrated into the classroom, consisted of a one-minute video of breathing exercises (Headspace, 2018) followed by professor-led recitation of positive affirmations. The utilization of brief breathing exercises as well as positive affirmations was structured after the intervention of Samuel and Warner (2021) and Samuel et al. (2022). The five positive affirmations, also utilized by Samuel and Warner (2021), were strongly influenced by growth mindset theory (Dweck, 2006; Yeager & Dweck, 2020). This intervention was distinct from Samuel and Warner's (2021) as the breathing exercises in video format were more standardized and thus able to contribute to educational resources that are easy for educators to implement. The professors in the sections utilized the intervention to start class during each class period, which was then followed by standard instruction. Students were reminded that they do not have to participate in the exercises, but they are asked to remain quiet and not distract other students. Both sections that were assigned to the control group received standard classroom instruction without any intervention.

Affective Measures

Mindful Attention Awareness Scale

The Mindful Attention Awareness Scale (MAAS) was utilized to evaluate whether the mindfulness-based intervention influenced the mindfulness of the participants. The MAAS is a 15-item instrument in which participants rate items on a 6-point Likert scale, from "almost always" to "almost never" (Brown & Ryan, 2003; MacKillop & Anderson, 2007). This includes statements such as "I could be experiencing some emotion and not be conscious of it until some time later" and "I snack without being aware that I'm eating." This instrument is widely used and has been validated as an assessment of mindfulness within an undergraduate sample (MacKillop & Anderson, 2007). The MAAS is best fit as a single factor, reflecting one's level of awareness of the present moment (Brown & Ryan, 2003). Scores on each question were summed to calculate a total, with higher scores indicative of higher mindfulness. The MAAS demonstrated good internal reliability in previous research ($\alpha = 0.89$; MacKillop & Anderson, 2007).

Revised Math Anxiety Rating Scale

The Revised Math Anxiety Rating Scale (RMARS) is a valid and reliable revision (Plake & Parker, 1982), as well as one of the most frequently implemented versions of the 98-item original Math Anxiety Rating Scale (Richardson & Suinn, 1972). The RMARS quantifies the participants' anxiety in response to various math situations on a 5-point Likert scale. Responses are then summed to determine a total level of math anxiety. Within the 24-item scale, there are two subscales corresponding to learning math anxiety and mathematics evaluation anxiety (Plake & Parker, 1982). Situations from the learning math anxiety subscale include "signing up for a course in Statistics" and "starting a new chapter in a math book." In contrast, statements from the evaluation anxiety subscale include "thinking about an upcoming math test one day before" and "being given a 'pop quiz' in a math class." Internal reliability in a sample of undergraduate and

graduate students was high (α=.98). Additionally, the RMARS has a strong correlation with the original Math Anxiety Rating Scale (*r*=.97; Plake & Parker, 1982).

Performance Measures

The math performance of students will be calculated across three distinct categories for assignments: exams, homework, and quizzes, based on the theoretical foundation from Bellinger et al. (2015), suggesting assignments with different stakes may have different relationships with mindfulness and anxiety. The specific grades for each assignment were reported by the professor as point values which were subsequently converted to percentages. The PSYC 354 classes completed three exams, 11 quizzes, and nine homework assignments. In contrast, the PSYC 355 classes completed four exams, 13 quizzes, and 12 homework assignments.

Homework assignments and quiz assignments completed prior to the first exam (which was taken during Week 5 for both classes) were averaged into Homework Average 1 and Quiz Average 1, respectively. Homework and quiz assignments completed in between the first exam and the second exam (which was taken during Week 9 for both classes) were averaged in Homework Average 2 and Quiz Average 2, respectively. Homework and quiz assignments completed after the second exam and before the final exam (which was taken Week 15 for both classes) were averaged in Homework Average 3 and Quiz Average 3, respectively. Students in PSYC 355 completed an additional exam in Week 9 which was averaged with their scores for the final exam to enable simpler comparison between courses. Comparison of final exam grades with and without averaging the third exam for PSYC 355 did not result in any significant changes. This enabled the differing assignments between courses to be consolidated into three homework scores, three quiz scores, and three exam scores, while still reflecting their progression over the semester.

Engagement in the Intervention

At the final time of assessment, the intervention group rated their self-reported engagement with the intervention. Students indicated their level of engagement with the intervention on a sliding scale from 0 to 100. For this scale, a higher score indicated higher engagement.

Qualitative Data Collection

In addition to quantitative data, a qualitative component was utilized at pretest and posttest in both the intervention and control groups to shed light on the perception of the intervention and its impact in comparison to experience in a classroom that received only standard instruction. This consisted of semi-structured interviews which were audio-recorded and transcribed verbatim. Interviews were conducted with six participants at the beginning of the semester, three participants from the intervention group and three participants from the control group. A total of four participants were interviewed at the end of the semester, two of which were from the intervention group while the other two participants were from the control group. Following the transcription, recordings were deleted. For the pre-intervention inquiry, questions centered around experience with math anxiety, prior experiences in math or statistics courses, and attitudes towards mindfulness. The posttest investigation focused on their current perception of math anxiety, experience in the course, factors contributing to their performance, perception of classroom environment, and attitudes towards mindfulness. For the intervention group specifically, the follow-up interview also included questions regarding their perception of the intervention and its effectiveness and barriers to the practice and impact of mindfulness in the classroom. As qualitative research generates such a rich level of detail, it was ideal for assessing

individual progress, changes in attitudes, and challenges experienced by the participants (Creswell & Poth, 2018).

Procedure

This study was approved by the university's institutional review board before the start of the semester. During the first week of classes, the students of PSYC 354 and PSYC 355 were introduced to the research project with an oral recruitment script by the researcher. Students that were willing to participate received an informed consent form and completed online surveys via Qualtrics, which included questions about demographic information, the RMARS, and the MAAS. During the ninth week of the semester, students completed a second round of the same surveys. At the end of the semester, students completed the final round of assessments. In addition, some participants consented for the instructors of their class section to report deidentified grades at the end of the semester to the researcher.

Data Analysis

To boost sample size and power, the two separate classes receiving the breathing exercises and positive affirmations were evaluated as a combined "intervention group," with the two classes that did not receive the intervention functioning as a combined "control group." However, due to the distinctive nature of PSYC 354 and PSYC 355, class differences were explored. As an embedded design, the quantitative analyses were the focal point while qualitative analysis was utilized to provide a deeper understanding of the intervention's impact.

Quantitative Statistical Analyses

Preliminary data screening was conducted to ensure the data met the necessary assumptions of normality, sphericity, and homogeneity of variance, as well as check for skewness, kurtosis, and presence of multivariate or univariate outliers (Martin & Bridgmon,

2012). The research design was 3 (within-subjects factors) x 2 (between-subjects factors). SPSS Statistics 28.0 was utilized to conduct the statistical analyses. Repeated measures analyses of variance (ANOVAs) were conducted for each of the affective measures (MAAS and RMARS). Each affective dependent variable was assessed at three points enabling within-subjects comparison across repeated measures and between-subject comparison, contrasting the intervention group with the control group. For the performance variables, a total of three repeated measures ANCOVAs were utilized to evaluate differences in performance while controlling for pretest level of math anxiety and mindfulness; thus, enabling insight into whether the affective impact of the intervention translated to an impact on performance in the course. Each univariate analysis was computed with a Bonferroni correction, to protect against elevated risk of Type I error that accompanies multiple comparisons (Warner, 2021). These analyses were chosen to demonstrate the group differences over time while statistically accounting for individual differences (Warner, 2021).

Qualitative Thematic Analyses

As the research design was an embedded mixed methods design, the qualitative data was utilized to supplement the quantitative findings (Creswell et al., 2011). The analysis of the qualitative data followed a phenomenological approach, utilizing thematic analysis to describe the essence of participant experiences in a classroom with the intervention compared to a standard classroom without the intervention. For each transcript, the researcher read through the text, making notes in the margin, and noting significant statements (Creswell & Poth, 2018). These significant statements were then grouped into meaningful units and overarching codes. Through immersion in the data, the codes were iteratively integrated into themes and refined to contribute to better understanding and meaning of the experience (Williams & Moser, 2019).

This enabled the researcher to boil down the transcripts into participant understandings of math, math anxiety, and mindfulness. Additionally, thematic comparison was utilized to compare themes within-subjects, contrasting themes of the beginning and end of the semester, as well as between-subjects, contrasting themes from the control and intervention group.

Chapter 4: Results

Data Cleaning and Assumptions

Missing data at the level of a question was filled in with the median or mean of the variable, depending on its skew. For normally distributed variables, the mean was computed for the missing data point. For skewed variables, the median was computed since the mean would not have accurately reflected a variable with a skewed distribution. Addressing missing data through measures of central tendency is appropriate since less than 5% of the data points were missing. Students that took the surveys at Time 1 but not at Time 2 or Time 3 were excluded from relevant repeated measures analyses but kept in pre-test analyses to maximize sample size.

A Shapiro-Wilk test indicated that RMARS scores and MAAS scores for Times 1, 2, and 3 were approximately normally distributed ($p>.05$). This is further supported by visual inspection of histograms and Q-Q plots. Additionally, the variables were not significantly skewed or kurtotic. Homework (HW) grades and Quiz grades across all three times were significantly skewed and kurtotic. Additionally, the Shapiro-Wilk statistic suggested significant departure from normality ($p<.05$) which is supported by visual analysis of histograms and Q-Q plots. Exam grades at Time 1 and Time 2 were not significantly skewed or kurtotic, however, the Shapiro-Wilk statistic and visual analysis of histograms and Q-Q plots suggested significant departure from normality ($p<.05$). Statistical and visual analyses of exam grades at Time 3 and Final Grade were significantly skewed and kurtotic, as well as not normal ($p<.05$). However, Rasch and

Guiard (2004) and Havlicek and Peterson (1974) suggest that the ANOVA and *t*-tests are robust against violations of normality; thus, the intended parametric tests were used for the analysis.

Scores on the RMARS, MAAS, and HW grades failed to meet the assumption of sphericity ($p<.05$) and thus were analyzed with the Greenhouse-Geisser correction to provide a more conservative estimate of impact (Sullivan, 2008; Warner, 2021). Quiz and Exam grades met the assumption of sphericity ($p>.05$). All variables except for HW grades met the assumption for homogeneity of variance. Analysis of scores for the RMARS and MAAS suggest no univariate or multivariate outliers. Several of the performance measures had one to two univariate outliers. Regression analysis to assess Mahalanobis distance revealed two multivariate outliers for grades, however, as they appeared to accurately reflect the population of interest and their removal did not affect other assumptions, they were kept in the data set per recommendation of Leys et al. (2019).

Descriptive statistics and reliability were analyzed for the two sections for mindfulness (assessed via the MAAS) and math anxiety (measured with the RMARS; See Table 1). Additionally, descriptive statistics were assessed for the performance measures, Homework (HW) grades, Quiz grades, and Exams grades, and Final grade (See Table 2). Self-reported engagement in the intervention, which was reported by the intervention group at the final time of assessment, reflected a negatively skewed, bimodal distribution, which rendered the mean and median ineffective at describing the results. Fifteen percent of students reported low engagement, ranging from 10 to 20 which comprised the minor mode, while 32.3% reported higher engagement, ranging from 80-90, which comprised the major mode. Further analyses on the impact of engagement are included in the Appendix.

Table 1

Descriptive Statistics and Reliability for Emotional Variables

Variable	Intervention		Control		
	M	*SD*	*M*	*SD*	Cronbach's α
Math Anxiety					
Time 1	74.36	17.41	68.61	16.77	.94
Time 2	67.69	15.74	64.48	14.52	.93
Time 3	66.41	15.72	61.26	13.17	.93
Mindfulness					
Time 1	48.58	12.67	54.51	10.98	.87
Time 2	48.71	11.49	51.78	10.24	.85
Time 3	48.61	11.11	52.18	11.25	.86

Table 2

Descriptive Statistics for Math Performance Variables

Variable	Intervention		Control	
	M	*SD*	*M*	*SD*
HW Grades				
Time 1	84.05	22.04	89.73	12.88
Time 2	88.65	15.56	93.15	4.57
Time 3	85.60	17.03	92.51	10.86
Quiz Grades				
Time 1	83.09	11.63	88.14	9.78
Time 2	89.49	10.39	91.56	13.33
Time 3	81.45	14.33	84.33	13.29
Exam Grades				
Time 1	76.61	11.97	81.38	12.23
Time 2	79.09	10.65	83.39	12.39
Time 3	77.48	10.82	82.65	13.66
Final Grade	82.83	8.80	87.42	8.21

Research Question 1

In order to assess the relationship between the study variables and demographic variables without any intervention impact, Pearson's *r* correlations were computed for the Time 1 assessment (Table 3). Mindfulness and Math Anxiety were significantly negatively correlated (r=-.21, p=.038). Math anxiety negatively correlated with Quiz 1 averages; however, it did not

reach significance (r=-.20, p=.058). Math anxiety significantly negatively correlated with performance on the first exam (r=-.27, p=.013) and Final Grade (r=-.27, p=.012). Mindfulness did not correlate with any HW Grade, Quiz Grade, Exam Grade, or Final Grade. Age significantly correlated with Math Anxiety (r=.22, p=.027), Exam Grade (r=-.29, p=.006), and Final Grade (r=-.27, p=.01) such that older students were more likely to have higher math anxiety and worse grades for Exam 1 and overall Final Grade. Gender significantly correlated with HW Grades (r=.38, p<.001), Quiz Grades (r=.24, p=.023), and Final Grade (r=.37, p<.001), such that females were more like to have higher performance on HW, Quizzes, and course performance overall.

Table 3

Pearson Correlation Matrix

Variable	*N*	1	2	3	4	5	6	7	8	9
1.RMARS	99	--								
2. MAAS	99	-.21*	--							
3. HW	87	.01	.13	--						
4. Quiz	87	-.20	-.03	.27*	--					
5. Exam	87	-.27*	.08	.41**	.49**	--				
6. Final	87	-.26*	.14	.72**	.60**	.68**	--			
7. Age	99	.22*	.08	-.20	-.12	-.29**	-.27*	--		
8. Gender	99	.16	-.06	.38**	.24*	.20	.38**	-.19	--	
9. Race	98	-.03	.17	.00	.00	-.10	-.04	.09	.20*	--

*p<.05. **p<.01.

Research Question 2

Mindfulness

To address the affective impact of the intervention on mindfulness, repeated measures analysis of variance (ANOVA) was utilized with the Greenhouse-Geisser correction due to failure to meet the assumption of sphericity. The ANOVA revealed an insignificant effect of time F(1.75, 124.04)=2.167, p=.125, partial η^2 = .03, an insignificant effect of section, F(1,

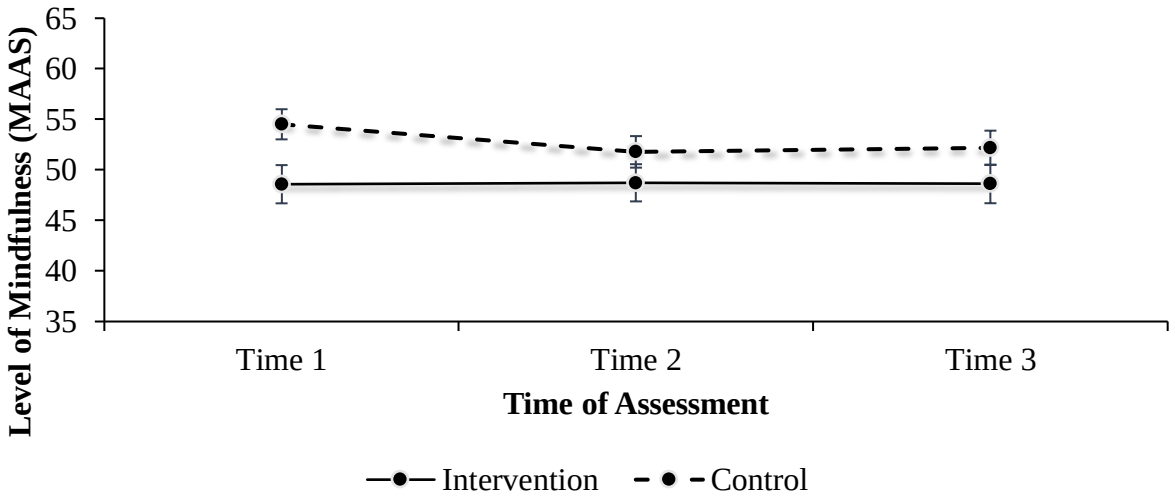
71)=2.557, p=.114, partial η^2 =.04, and an insignificant time by section interaction, F(1.75, 124.04)=1.321, p=.269, partial η^2 = .02 (See Figure 1). However, observed power was low for analysis of the effects, ranging from .264 to .407, thus, it was followed with more powerful exploratory analyses despite the insignificant effects.

Three independent samples *t*-tests were utilized to compare group differences at each time of assessment. At Time 1, the control group had statistically significantly higher levels of mindfulness (M=54.51, SD=10.98) compared to the intervention group with a moderate effect size (M=48.58, SD=12.67), t(97)=2.498, p=.007, Cohen's d=.504. At Time 2, the control group (M=51.78, SD=10.24) was not significantly higher than the intervention group (M=48.72, SD=11.49), t(80)=1.276, p=.103, Cohen's d=.282. Additionally, at Time 3, the control group (M=52.18, SD=11.25) was not significantly different from the intervention group (M=48.61, SD=11.11), t(76)=1.395, p=.084, Cohen's d=.319.

Two paired samples *t*-tests were utilized to compare changes over the course of the semester between groups. The control group had a significant decrease from Time 1 (M=55.20, SD=11.35) to Time 3 (M=52.18, SD=11.25), t(43)=2.219, p=.016, Cohen's d=.34. This difference would not be statistically significant with a Bonferroni correction, however, given the exploratory nature of these analyses, a standard α=.05 was used. This decrease corresponded to an average four percent reduction in mindfulness from Time 1 to Time 3 for the control group. The paired samples *t*-test for the intervention group did not find any significant changes from Time 1 (M=48.62, SD=11.47) to Time 3 (M=48.62, SD=11.11), t(33)=.002, p=.499, Cohen's d=.00.

Figure 1

Changes in Mindfulness over the Semester



Math Anxiety

A repeated measures ANOVA to evaluate the impact on math anxiety revealed a significant effect of time, $F(1.521, 107.992)=10.287$, $p<.001$, partial $\eta^2 = .13$. There was an insignificant effect of section, $F(1, 71)=2.553$, $p=.115$, partial $\eta^2 = .04$, and an insignificant time by section interaction, $F(1.521, 107.992)=.577$, $p=.518$, partial $\eta^2 = .008$ (See Figure 2). However, when covariates of age and gender are included in the model, there was a significant effect of section, $F(1,69)=4.528$, $p=.037$, partial $\eta^2 = .06$; however, this is insignificant with the Bonferroni correction. The time and the time by section interaction remained insignificant $p=.205$ and $p=.385$, respectively. Similar to the analysis on mindfulness, observed power was insufficient to detect significant effects, ranging from .132 to .351, which motivated more powerful exploratory analyses.

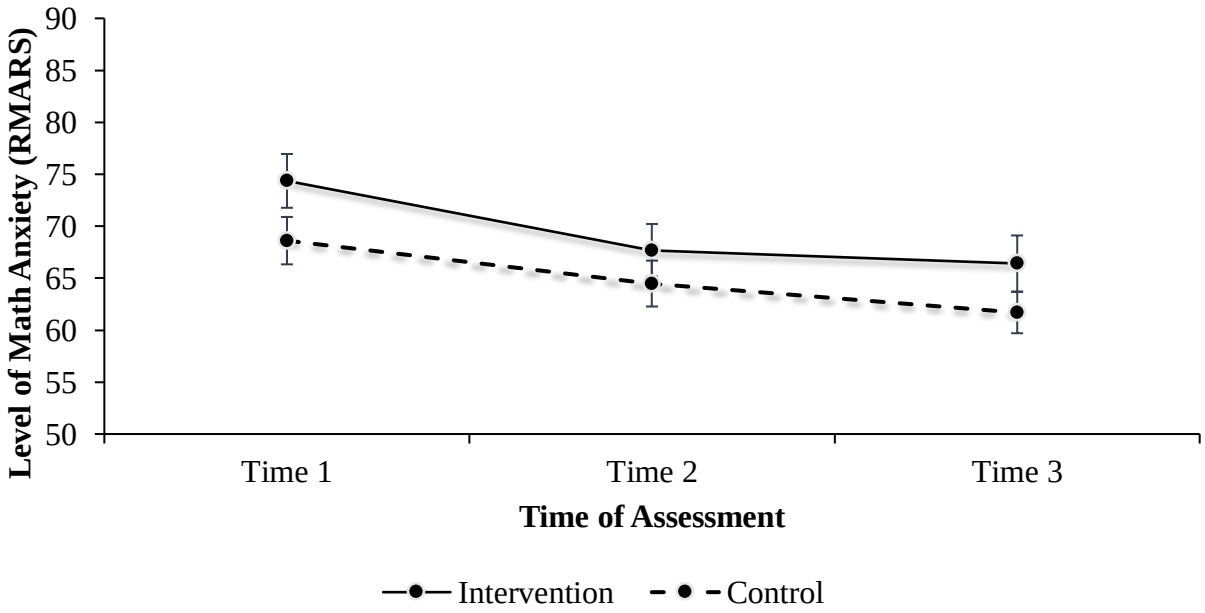
Three independent samples *t*-tests were utilized to evaluate differences between sections at each time of assessment. The control group ($M=68.61$, $SD=16.77$) had lower math anxiety than the intervention group ($M=74.36$, $SD=17.41$) at Time 1, $t(97)=-1.668$, $p=.049$, Cohen's

d=.34. Differences between the control group (*M*=64.48, *SD*=14.52) and the intervention group (*M*=67.69, *SD*=15.75) were insignificant at Time 2, *t*(80)=-.960, *p*=.17, Cohen's *d*=.21. Similarly, differences between the control group (*M*=61.26, *SD*=13.17) and intervention group (*M*=66.41, *SD*=15.73) were insignificant at Time 3, *t*(76)=-1.573, *p*=.06, Cohen's *d*=.36.

Two paired samples *t*-tests were utilized to compare changes over the course of the semester for the intervention group and the control group. A paired samples *t*-test on the control group revealed a significant difference between Time 1 and Time 3, *t*(43)=2.283, *p*=.014, Cohen's *d*=.344. The average percent change for the control group was a four percent reduction in math anxiety from Time 1 to Time 3. Additionally, a paired samples *t*-test revealed the intervention group also had a significant decrease from Time 1 to Time 3, *t*(33)=3.195, *p*=.002, Cohen's *d*=.55. The average percent change for the intervention group was an eight percent reduction in math anxiety from Time 1 to Time 3.

Figure 2

Changes in Math Anxiety over the Semester



Research Question 3

To address the extent to which the affective impact of the intervention translated to an impact on grades, three repeated measures analyses of covariance were utilized for each of the grade outcomes. These analyses controlled for demographic factors and Time 1 levels of mindfulness and math anxiety. Additionally, final grades between sections were compared with independent samples *t*-tests as well as an analysis of covariance controlling for demographics and Time 1 levels of mindfulness, math anxiety, and grades.

Impact on Homework

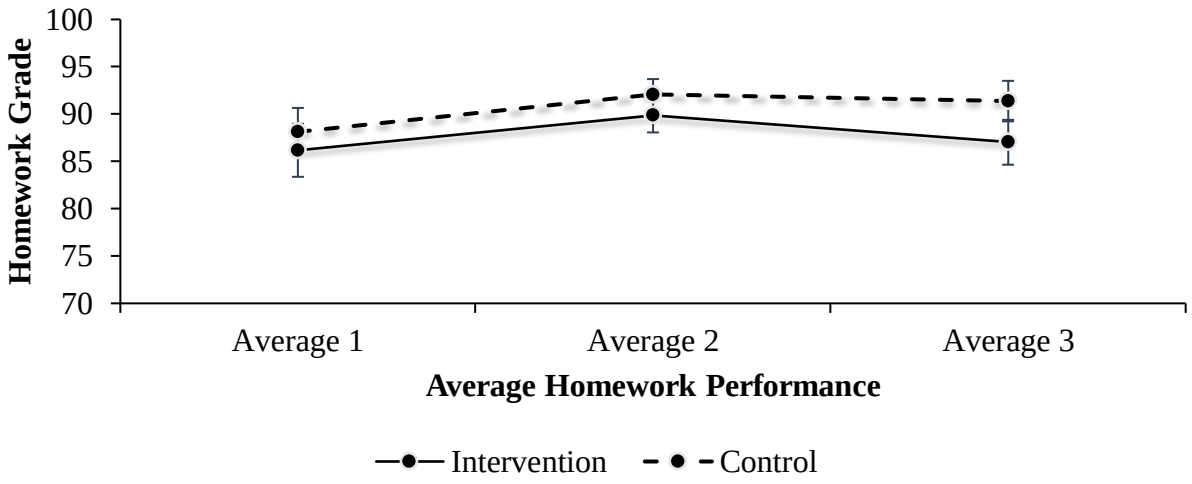
A repeated measures analysis of covariance was utilized to compare changes in homework (HW) scores over the semester between the two groups. This revealed an insignificant effect of time, $F(1.743, 137.72)=2.465$, $p=.095$, partial $\eta^2 =.03$, an insignificant effect of section, $F(1, 79)=.988$, $p=.323$, partial $\eta^2 =.01$, and an insignificant time by section interaction, $F(1.743, 137.72)=405$, $p=.525$, partial $\eta^2 =.01$ (See Figure 3). Similar to the analyses on math anxiety and mindfulness, these analyses were underpowered, with observed power ranging from .11 to .49, which motivated exploration with more powerful analyses.

Independent samples *t*-tests between the control group and intervention group at each time suggest that at Time 1, the control group ($M=89.73$, $SD = 12.88$) had insignificantly higher HW grades, $t(85)=1.499$, $p=.069$, Cohen's $d=.323$ compared to the intervention group ($M=84.05$, $SD=22.04$). At Time 3, the control group ($M=92.52$, $SD=10.86$) had significantly higher HW grades, $t(85)=2.30$, $p=.012$, Cohen's $d=.49$, compared to the intervention group ($M=85.60$, $SD=17.03$). For the control group, paired samples *t*-tests suggest an insignificant increase from Time 1 ($M=89.73$, $SD=12.88$) to Time 3 ($M=92.52$, $SD=10.86$), $t(47)=1.33$, $p=.095$, Cohen's $d=.192$, improving by an average 7.55%. Similarly, paired samples *t*-tests for the intervention

group suggest an insignificant increase from Time 1 (*M*=84.05, *SD*=22.04) to Time 3 (*M*=85.60, *SD*=17.03), *t*(38)=.633, *p*=.265, Cohen's *d*=.10, improving by an average of 5.62%.

Figure 3

Changes in Homework Averages over the Semester



Impact on Quizzes

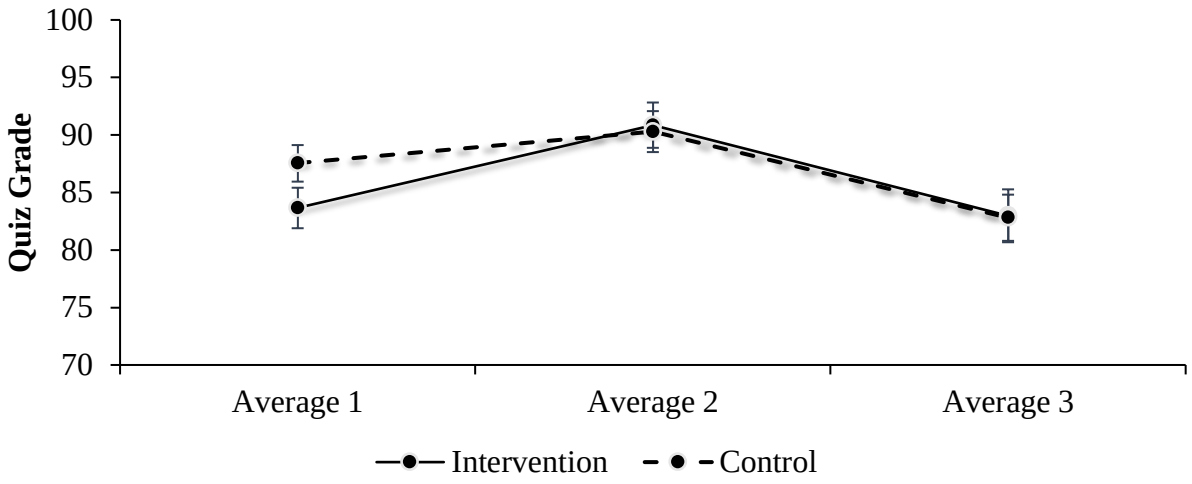
To evaluate the differences in changes in moderate-stress assignments over the semester between the intervention and the control group, a repeated measures ANCOVA was utilized on quiz averages controlling for demographic factors and Time 1 levels of mindfulness and math anxiety. This revealed an insignificant effect of time, $F(2, 158)=.359$, $p=.699$, partial $\eta^2 =.01$, an insignificant effect of section, $F(1, 79)=.281$, $p=.597$, partial $\eta^2 =.004$, and an insignificant time by section interaction, $F(2, 158)=.966$, $p=.379$, partial $\eta^2 =.01$ (See Figure 4). Observed power was low, ranging from .08 to .21 and thus was also followed with more powerful analyses.

Independent samples *t*-tests on Quizzes at Time 1 suggest that the control group (*M*=88.14, *SD*=9.77) had significantly higher grades than the intervention group (*M*=83.09, *SD*=11.63), *t*(85)=2.20, *p*=.015, Cohen's *d*=.47. The control group (*M*=84.33, *SD*=13.29) and the intervention group (*M*=81.45, *SD*=14.33) were not significantly different at Time 3, *t*(85)=.971,

p=.167, Cohen's *d*=.21. When controlling for pre-test levels of math anxiety, mindfulness, and demographic factors, the intervention group (estimated *M*=82.97, *SE*=2.30) slightly outperformed the control group (estimated *M*=82.8, *SE*= 2.07). Paired samples *t*-tests for the control group suggest a significant decrease from Time 1 (*M*=88.14, *SD*=9.77) to Time 3 (*M*=84.33, *SD*=13.28), *t*(47)=2.40, *p*=.010, Cohen's *d*=.35. In contrast, the intervention group had an insignificant decrease from Time 1 (*M*=83.09, *SD*=11.63) to Time 3 (*M*=81.45, *SD*=14.33), *t*(38)=.642, *p*=.263, Cohen's *d*=.10. The control group decreased on average 4.00%, whereas the intervention group decreased an average of less than 1%.

Figure 4

Changes in Quiz Averages over the Semester



Impact on Exams

To evaluate the impact of the intervention on high-stress assignments, a repeated measures ANCOVA on exam scores controlling for demographic factors and Time 1 math anxiety and mindfulness was utilized. This revealed an insignificant effect of time, *F*(2, 158)=.217, *p*=.805, partial η^2 =.003, an insignificant effect of section, *F*(1, 79)=1.422, *p*=.237, partial η^2 =.02, and an insignificant time by section interaction effect, *F*(2, 158)=.040, *p*=.961,

partial η^2 =.001. As with the first analyses, lack of sufficient power (ranging from .06 to .22) motivated exploration with more powerful analyses.

The results of independent samples *t*-tests for exam scores are summarized in Table 4. These suggest that the intervention group was significantly lower than the control group across all three exams. Paired samples *t*-tests for the control group suggest there was an insignificant increase from Exam 1 to Exam 3, $t(47)=.813$, $p=.210$, Cohen's $d=.12$. This corresponded to an average 2.16% increase. For the intervention group, there was similarly an insignificant increase from Exam 1 to Exam 3, $t(38)=.441$, $p=.331$, Cohen's $d=.07$, corresponding to an average 3.09% increase. Means and standard deviations of exam scores for control and intervention group are also reported in Table 4.

Figure 5

Changes in Exam Scores over the Semester

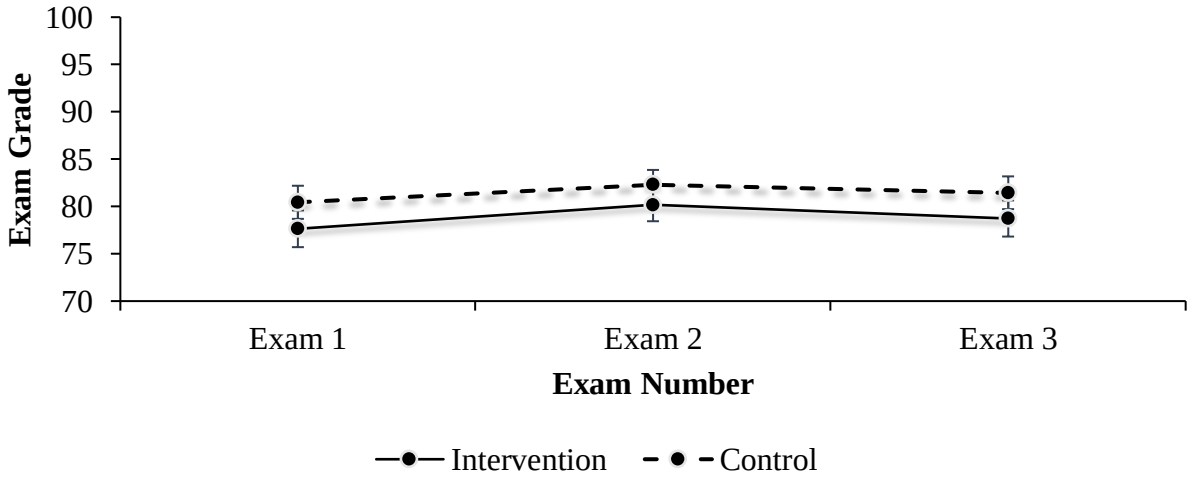


Table 4

Results of Independent Sample t-tests for Exams

Exam	Intervention		Control		*t*(85)	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Exam 1	76.61	11.97	81.38	12.23	1.827	.036	.394
Exam 2	79.09	10.65	83.39	12.39	1.711	.045	.369
Exam 3	77.48	10.82	82.65	13.66	1.921	.029	.414

Final Grade

To compare differences in final grade between the two sections, an independent samples *t*-test was utilized. This found that the control group (*M*=87.41, *SD*=8.21) scored significantly higher than the intervention group (*M*=82.83, *SD*=8.80), *t*(85)=2.507, *p*=.007, Cohen's *d*=.54. However, an ANCOVA on final grade controlling for demographic factors and Time 1 levels of math anxiety and mindfulness rendered the difference insignificant, *F*(1, 79)=1.393, *p*=.241, partial η^2 =.02. As final grade is comprised of homework, quiz, and exam performance, the intervention group's lower performance across homework and exams was buffered by their improvements in quiz performance.

Research Question 4

Thematic analysis was conducted according to Braun and Clark (2006) and Creswell and Poth (2018). Analysis of the pre-test interviews revealed several themes. Participants perceived 1) mindfulness as emotional and cognitive, 2) math anxiety as multifaceted in nature and impact, and 3) success in the course as contingent on both external and internal factors.

Mindfulness as Emotional and Cognitive

Participants generally perceived mindfulness as an effortful awareness of both cognition and emotion, "I think being present, in the moment, being mindful about, you know, what's going through my head. What did I think about, did the way I'm feeling now, is that the result of

what I was thinking about" (Participant 1). Moreover, this awareness is non-judgmental and accepting of the thoughts and feelings that one experiences, "replaying [your day] in your mind and sorting through what you were thinking at the time and how you were feeling at the time and kind of sorting that into your mind and letting it kind of run" (Participant 2). Lastly, they perceived this present awareness as requiring intentionality and effort, "mindfulness [is] taking time out of your day to dedicate to just being with – alone with yourself and like sorting through thoughts" (Participant 2).

In addition to being emotional and cognitive in nature, mindfulness impacts individuals both cognitively and emotionally. The cognitive impact is apparent in enabling one's brain to relax, as one participant described mindfulness as "giving yourself time […] just let your brain take a break and just sort through everything that's happened to it throughout the day. And so it helps- it helps your brain just adapt and stay- stay healthy" (Participant 2). Participants also perceived an emotional benefit through mindfulness, such as coping with anxious thoughts, "when I wake up sometimes the first thing I think about is, it's always like an anxious thought most of the time, so taking that into account […] be mindful of the fact that I do have those anxious thoughts." (Participant 3). Participants experienced their mindfulness as contributing to emotional and cognitive control, "mindfulness is being aware of your current emotional and mental state and what influences that and then how you can control your environment or yourself to affect that" (Participant 4).

The Multifaceted Nature and Impact of Math Anxiety

Nature of Math Anxiety. Participants perceived math anxiety as related to competence, beliefs, and their environment. Some described their lack of competence in math and concerns about passing as contributing to their anxiety, "I've never been great at math. So, I have anxiety

in it" (Participant 3). Math anxiety was also related to self-efficacy and perception of ability. Several participants described their anxiety towards statistics as stemming from anxiety about numbers, "When I think of statistics, I'm like, wow, that is scary. There's a lot there. I think more so it's a lot of numbers" (Participant 3). The classroom environment and social situation can impact one's anxiety and their outcome. Additionally, just being in a statistics class elevated their anxiety, "I just got out of stats class, so I'm a little bit more anxious." (Participant 5).

Math Anxiety's Cognitive, Physical, and Behavioral Impact. Participants perceived math anxiety as impacting physiology, behaviors, and performance. The physical impact of math anxiety was described as headaches and nervous picking or scratching. Participants described anxiety as reducing outcomes through impacting class engagement and mindfulness:

> I think it goes back to if I am drowning in doubt and fear, the outcome will not be good, because it's kind of like saying, 'forget it, I don't understand it.' So, I'm not engaged. I'm not mindful, not present in the class. Which doesn't lead to good grades. (Participant 1).

Math anxiety also impacts enrollment decisions, "like the courage that some people need to gather to be able to sign up for one in the first place can be really stressful… just the word math can scare people" (Participant 2). One participant expressed that math anxiety really contributed to struggles with learning, despite the efforts they made in the class, "But no matter what it just seemed like my brain just could not understand it" (Participant 3).

Factors Contributing to their Success

External. Many students described the value of the professor in communicating the content and making the class more enjoyable, "I feel like I really enjoy the Professor… he does a good job of presenting the material and going over it." (Participant 3). Another student remarked, "they're kind of there as a guide to help you get to the destination […] I could not learn a subject

that I'm not good at, like statistics, without a professor." (Participant 4). They also perceived the professor as a resource they could turn to for help. The professor was also perceived as setting the emotional tone of the classroom, which contributed to their engagement and success, both in this class and in prior math experiences, "if the math teacher is just droning and boring, then nobody's going to be invested because it's math, nobody's going to be invested" (Participant 2). Moreover, the resources offered by the professor, such as tutoring, were perceived as contributing to success.

In addition to the professor, the classroom as a whole was considered influential for students' success. Failure to engage in a class was perceived as a barrier, "because when there's a little bit of doubt, like I should probably ask a question because I don't fully understand this. But usually I just let it slide and I don't actually learn so, ask questions… so not asking questions is a barrier" (Participant 1). The classroom also provided access to a community of classmates that enabled collaboration and deeper understanding, "it's really nice to have these other people that can understand concepts, that I can't understand, so we can bounce off each other and hopefully, do well on the exam" (Participant 6). Several students expressed the value of turning to other students when faced with challenges, "I think that emotionally, when you're in the class, I think that when other people are coming alongside you […] you have people that can tell you, like it's okay if you're struggling, you know, you're not alone in this" (Participant 3). Students considered the classroom environment, which was shaped by the professor, as influential on engagement, confidence, and success in the course.

Internal. Students perceived internal elements such as one's efforts, motivation, and ability as contributing to their success in the course. Students thought of statistics as a course that required a lot of effort. Moreover, effort was perceived as more important than innate ability, "I

know math is a hard subject for me, but I need to put in extra time because it's a weakness and then I can eventually gain understanding." (Participant 4). Another participant expressed, "I think intelligence probably does play some part in that too, some people are naturally blessed in that, and others not so much, but I think it really determines like, how much effort are you putting into it?" (Participant 3). Additionally, seeing the purpose in the statistics class can impact engagement and anxiety, one participant said, it is "important that I know what the purpose of everything that I'm studying is about. I don't like not knowing those things, because then I'm wasting my time and then I don't know what to focus on, which adds to anxiety" (Participant 6).

Additionally, internal elements such as one's thoughts and ruminations could contribute to someone's success. Negative self-talk functioned like a self-fulfilling prophecy, "a lot of times I would say in elementary and middle school that 'I can't do this' and that would be a self-fulfilling prophecy" (Participant 4). Math anxiety related to one's perception and beliefs which influenced their motivation and success, "I'd say probably the biggest barrier is the ones we make for ourselves. As in like, whenever we, whenever we tell ourselves that we're bad at math, and so we become worse at math because of, because we keep telling ourselves that." (Participant 2).

These qualitative results suggest that students perceive a cyclical relationship between mindfulness, anxiety, and course outcomes. They viewed mindfulness as impacting their anxiety; however, their anxiety also impacts their mindfulness. Moreover, mindfulness impacts one's engagement and ability to prepare. Lastly, one's preparedness contributes to their degree of anxiety. The perceived interrelations between mindfulness, anxiety, and performance are aptly described by one of the post-test interviews:

> Because yeah, if you're not mindful beforehand, and you're feeling stress and anxious, probably not going to help that, like you're unprepared. But like preparedness, I feel like also connects to mindfulness. So it's like all the big circle. Mindfulness affects how hard you study and how well you can study and then that affects preparedness. Then preparedness, if you're not prepared, you haven't studied, your mindfulness probably isn't the best and it's a lot so just start with mindfulness and be mindful of yourself and how you're feeling. (Participant 5)

Post-test Qualitative Results

Thematic analysis of post-test interview transcripts from the intervention group revealed several themes regarding the intervention's impact as well as barriers to the intervention's success. To further evaluate its impact, the post-test transcripts from the intervention group were compared with the control group. This thematic comparison revealed differences between the two groups in their perceived growth in mindfulness, math anxiety, and perception of statistics over the course of the semester.

Impact of the Intervention

Intervention Benefited Emotions. When asked about the impact of the intervention, both intervention group participants suggested that the intervention calmed the classroom environment, "that exercise just kind of made everybody like a lot quieter and […] more calm afterwards." (Participant 7). The breathing exercises helped to reduce anxiety and brought a sense of relief, "I always found that after doing the video was always super helpful and I felt way better after" (Participant 7). Investing the time to take a few breaths was viewed positively by the participants, helping to reduce their anxiety.

Intervention Prepared Class to Learn. There were also cognitive impacts because of the intervention. Both participants suggested the intervention prepared themselves and the class as whole for being engaged in class, one participant expressed, “like even the people that didn't participate in it. Everybody was just ready to listen to what the professor had to say” (Participant 7). The other said, “I was like confused about [the intervention]. But then going on, I was like, maybe I should just give it a try. And that gave me a better mindset to be involved in the class.” (Participant 8). Specifically, the breathing exercises were noted as getting them ready to learn, while the affirmations helped them focus. The impact of the intervention was enhanced by the professor, as one student noted, “The professor would also repeat them and so that was helpful to hear that… he would say them with us and help us understand like, like I do believe that you can understand this lesson” (Participant 7).

Barriers. While both students expressed positive reception of the intervention, they recognized distractions could be a barrier to engaging in the intervention. Additionally, there were other students in the classroom who appeared disinterested in the intervention, "some people were just kind of okay with it happening, but they didn't really like engage and I'm not really sure why, but some people just didn't seem like super interested in it.” (Participant 7). They suggested this could be a barrier to the intervention’s effectiveness. One participant expressed that the freedom to engage or not engage in the intervention was important, “I think, how [the intervention] was done was really well, because there was no forcefulness […] And there was no judgment if you didn't participate" (Participant 8).

Differences Between Groups

Mindfulness. During post-test interviews, both participants in the intervention group expressed that their mindfulness increased over the course of the semester, while the participants

in the control group did not perceive any changes in mindfulness during the semester. However, both participants from the control group recognized the value of mindfulness. They even expressed it would be beneficial for the classroom to foster more mindfulness, “In the classroom… I mean it’s hard to learn. So it would be better to be mindful of how you’re feeling” (Participant 9). Additionally, one control participant suggested that math made being more mindful challenging, when asked if mindfulness has changed over the semester, they said “Not too much, probably because it has to do with like math, but also it has to do with like things that I haven't considered to be too applicable to my life and I think that's what makes it difficult” (Participant 10).

Math Anxiety. The trends in anxiety over the semester were more heterogenous in both groups. One intervention participant expressed their math anxiety had not changed, however, their awareness of it has helped them to perceive it as just a part of life, “just because my anxiety is still there. You’re still going to have anxiety through different ways in your life” (Participant 8). The other intervention participant described their math anxiety as decreasing over the semester, despite having previously struggled with math anxiety, “honestly, I think this is the like least math anxiety that I’ve ever had in a math course” (Participant 7). Moreover, they perceived this decrease is impacting their understanding and performance, “But I feel like over the course of this semester, my math anxiety has gone down tremendously. So I'm very thankful for that because now I'm able to like actually do well in the courses, whereas my anxiety almost prevented me from doing well” (Participant 7). The intervention participants expressed that mindfulness helped them control their anxiety, “just realizing that I can be mindful of whatever anxiety that I’m facing, but realize that it’s not, it doesn’t have to completely take over my life” (Participant 7). In the control group, one described their math anxiety as decreasing overall,

however, this was situational and impacted by factors like the upcoming exam, “I will say right now [my anxiety] kind of is increasing because I have my exam coming up” (Participant 10). The other participant in the control group experienced an increase in math anxiety during the semester, feeling overwhelmed by the content. Participants from the control group regretted not developing a better mindset because it could have benefited their academic success and anxiety:

> I think if my mindset was changed to where I could believe like, okay, like I understand it, this is all easy. Then things would have changed for me like grade wise, but also like attentive wise and class […] I probably would not be freaking out as much as I feel like I am about this final exam. (Participant 9)

Perception of Statistics. Transcripts from both groups underwent coding for positive, negative, and neutral statements regarding the professor, the classroom, and statistics. Despite both groups having comparable positive perceptions of the professor and the classroom community, participants from the two groups had distinct perceptions of statistics. The intervention group expressed more positive perceptions of statistics, for example, "when I think of statistics I will say, out of all the math classes I've ever taken, it's one that I found that I'm the best at which is very surprising, when you're not good at math” (Participant 7). In contrast, emotional tone of the content relating to statistics was more negative for the control group, when asked about statistics, one participant replied “numbers, calculations, populations, headaches” (Participant 9) while the other expressed, “I don’t like statistics. I don’t want to do it” (Participant 10).

Additionally, both participants from the intervention group described how their perception of statistics had shifted over the course of the semester, a shift which was not evident in the control group. The intervention group members expressed that they no longer perceived

statistics as just numbers, but rather saw an overarching purpose and value to statistics, “So I think my perspective has changed a lot on what do we do with statistics is really special like for psychology, it's how can we help others to the best of our ability” (Participant 7). Similarly, “throughout the semester, I've learned that statistics is used, not just for math or anything, it's used in the real world like psychology” (Participant 8). In contrast, a participant from the control group described that the professor explained the purpose of statistics, but they had difficulty keeping that purpose in mind, “I do [statistics] just to get it done, but like, then, I go back and I try to remember I'm like, I don't know why we did this.” (Participant 9). The other control group participant said, “I don’t see [statistics] being applicable” (Participant 10). The participants in the intervention group perceived better growth in mindfulness, felt more equipped to handle anxiety, and had more positive perceptions of statistics.

Further Exploratory Analyses

Exploration of Impact on At-Risk Students

The impact of the intervention was further explored by focusing on exclusively at-risk students. These students were defined as “at-risk” for failing or dropping out based on their performance in the first third of the semester. Students that were a half a standard deviation below the mean for HW 1 average, Quiz 1 average, and Exam 1 were categorized as “at-risk.” This included four students from the control group and three students from the intervention group. Despite this small sample, the intervention group (M=37.00, SD=10.54) had significantly lower mindfulness than the control group (M=61.50, SD=15.42), $t(4)=2.35$, p=.033, Cohen’s d=1.79. Comparison of the at-risk students for math performance outcomes is summarized in Table 5. The at-risk students in the intervention group started with lower quiz grades at Time 1, but higher quiz grades at Time 3. Although this did not reach significance, the effect size was

large, Cohen's *d*=.88. In the intervention group, students had lower exam scores than the control group with a small effect size. However, the final exam scores for the intervention group were higher than the control group, with a large effect size (Cohen's *d*=1.01). Additionally, the percent changes from Quiz 1 to Quiz 3 and Exam 1 to Exam 3 were greater for the intervention group than the control group, with large effect sizes (See Table 5). While the use of inferential statistics is debated for a very small sample, the large effect sizes and differences suggested by the independent samples t-test are supported by visual analysis of the students' progression over the semester (Hopkins et al., 2015). Of the four students in the control group deemed at risk, one student failed the class. In contrast, all three students from the intervention group that were at risk passed the class.

Table 5

Results of Independent Samples t-tests for At-Risk Students

Outcome	Intervention (*N*=3)		Control (*N*=4)		*t*(5)	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*			
HW 1	49.11	16.88	59.72	23.55	.657	.270	.50
HW 2	80.43	6.49	86.16	3.14	1.572	.088	1.20
HW 3	77.24	13.75	86.36	4.34	1.283	.128	.98
Quiz 1	68.75	11.92	70.42	15.84	.152	.443	.12
Quiz 2	95.56	7.69	71.67	23.33	1.671	.078	1.28
Quiz 3	81.40	12.61	70.14	12.84	1.156	.150	.88
Exam 1	59.68	13.73	61.32	5.94	.219	.418	.17
Exam 2	74.28	18.11	70.70	19.50	.247	.407	.19
Exam 3	80.23	10.05	57.89	27.20	1.329	.121	1.01
Final Grade	74.08	2.30	70.49	5.91	.977	.187	.75
Percent Change							
Quiz 1-Quiz 3	22.43	37.24	1.70	16.83	1.008	.180	.77
Exam 1-Exam 3	37.99	25.50	-8.37	39.29	1.762	.069	1.35

Exploration of Class Differences

While it was beneficial for sample size to consolidate the different class sections into a control group and intervention group, given the distinct nature of PSYC 354 and PSYC 355, it is

critical to evaluate the extent and nature of class differences. Independent samples *t*-tests between both PSYC 354 sections and both PSYC 355 section suggest significant differences in Time 1 levels of math anxiety, $t(97)=2.10$, $p=.019$, Cohen's $d=.427$, homework grades, $t(85)=5.89$, $p<.001$, Cohen's $d= 1.28$, and exam grades, $t(85)=2.709$, $p=.004$, Cohen's $d=.59$. Additionally, differences in changes over the course of the semester were evaluated with a two-way repeated measures ANOVA for each variable (See Table 6).

Table 6

Two-Way Repeated Measures ANOVA Results

Variable	*F*	df	*p*	Partial η^2
Math Anxiety				
Time by Class	.435	(2,138)	.648	.006
Time by Class by Section	.106	(2,138)	.900	.002
Mindfulness				
Time by Class	.066	(2,138)	.936	.001
Time by Class by Section	.744	(2,138)	.477	.011
Homework				
Time by Class	28.119	(2,166)	<.001	.253
Time by Class by Section	1.092	(2,166)	.338	.013
Quiz				
Time by Class	7.084	(2,166)	.001	.079
Time by Class by Section	.788	(2,166)	.457	.009
Exam				
Time by Class	2.633	(2,166)	.075	.031
Time by Class by Section	.460	(2,166)	.632	.006

The results in Table 6 suggest the classes and their respective sections had similar changes over the course of the semester for math anxiety, mindfulness, and exam scores. The comparable trends over the semester for most of the variables provide further support for the decision to consolidate groups and boost sample size. However, there was a significant Time by Class interaction effect for both Homework ($p<.001$) and Quiz grades ($p=.001$). For homework, pairwise comparisons suggest that PSYC 354 significantly decreased in their homework grades

from Time 1 (Control: *M*=94.96, *SD*=6.13; Intervention: *M*=95.81, *SD*=8.27) to Time 3 (Control: *M*=91.75, *SD*=13.62; Intervention: *M*=88.47, *SD*=12.31; *p*=.003). In contrast, PSYC 355 significantly increased in their homework grades from Time 1 (Control: *M*=82.4, *SD*=16.13; Intervention: *M*=68.82, *SD*=25.06) to Time 3 (Control: *M*=93.59, *SD*=5.09; Intervention: *M*=81.89, *SD*=21.55; p<.001).

For quizzes, pairwise comparisons suggest that PSYC 354 significantly reduced in their quiz grades from Time 1 (Control: *M*=88.33, *SD*=11.35; Intervention: *M*=83.03, *SD*=12.17) to Time 3 (Control: *M*=80.49, *SD*=14.46; Intervention: *M*=79.63, *SD*=9.57; *p*=.003). In contrast, PSYC 355 maintained their quiz grades, with an insignificant increase from Time 1 (Control: *M*=87.88, *SD*=7.31; Intervention: *M*=83.16, *SD*=11.26) to Time 3 (Control: *M*=89.71, *SD*=9.34; Intervention: *M*=83.81, *SD*=18.90; *p*=.566). Random assignment of section from both PSYC 354 and PSYC 355 to the intervention and control groups mitigates these different trends as each section that received the intervention is contrasted with the control section, enabling meaningful comparison with maximum sample size.

Chapter 5: Discussion

The purpose of this study was to investigate the relationship between mindfulness, math anxiety, and math performance. No known studies had evaluated the impact of an embedded video-based mindfulness and growth mindset intervention on student's mindfulness, math anxiety, and performance outcomes in the classroom. The first set of hypotheses predicted a negative relationship between mindfulness and math anxiety, a positive relationship between mindfulness and math performance, a negative relationship between math anxiety and quiz and exam performance, and no correlation between math anxiety and homework performance. The second set of hypotheses predicted the intervention group would have enhanced mindfulness and

reduced math anxiety compared to the control group. The third set of hypotheses predicted that the intervention group would have enhanced performance on quizzes and exams, but not homework grades, because of the different stakes of the assignments.

At the beginning of the semester, the intervention group had higher math anxiety, lower mindfulness, and worse math performance across homework, quizzes, and exams, compared to the control group. The control group had a level of math anxiety that is comparable to descriptive statistics for studies that specifically evaluated psychology students (i.e., Justicio-Galiano et al., 2016). This is higher than levels of math anxiety observed in other samples, such as preservice teachers (Wilson, 2013), but congruent with the findings that psychology students have elevated math anxiety compared to the general population (O'Leary et al., 2017). The intervention group had higher math anxiety than prior studies (Justicio-Galiano et al., 2016; O'Leary et al., 2017) as well as the control group.

Descriptive statistics for mindfulness assessed with the Mindful Attention Awareness Scale suggest that the control group had comparable mindfulness to what was observed in previous studies such as with preclinical medical students (Lampe & Müller-Hilke, 2021), and psychology students (Cosme & Wiens, 2015). However, the intervention group had lower mindfulness than prior research as well as the control group. While this coincides with their elevated levels of math anxiety (i.e., Weed et al., 2021), it highlights how there may be other individual differences between the two sections.

The pattern of outcomes for performance variables is consistent with previous research (i.e., Bellinger et al., 2015), such that students have higher performance on lower-stress assignments (homework grades) than moderate-stress assignments (quizzes), both of which have higher averages than high-stress assignments (exams). The group differences for math

performance at the beginning of the semester again suggest the intervention group was more at-risk, starting at a disadvantage with lower homework, quiz, and exam grades compared to the control group.

While the sections were randomly assigned, for both the PSYC 354 and the PSYC 355 classes, it was the second section that was assigned to receive the intervention while the first section was the control group. This random assignment appeared to create a sample in which the intervention group could be considered more at risk for lower socioemotional and academic outcomes through higher math anxiety, lower mindfulness, and worse math performance. Because the intervention group was the second section, which would generally be open for enrollment after the first section, it is possible that individuals in the second section were delaying enrolling in their statistics class, perhaps due to their elevated levels of math anxiety. This is supported by research which highlights the behavioral impact of math anxiety on enrollment decisions and avoidant behaviors (Ramirez et al., 2018; Richardson & Suinn, 1972; Rozgonjuk et al., 2020). This is also supported by the qualitative findings in the current study, which suggest that students perceive math anxiety as impacting enrollment decisions and the motivation to sign up for a statistics class. The impact of this later enrollment on the differences between sections could also be related to other factors such as motivation and preparedness. Freer-Weiss (2004) found that later enrollment was associated with lack of preparedness, such as lower prior academic performance, more remedial coursework, and higher rates of attrition. Similarly, Smith (2002) and Hale and Bray (2011) found that later registration time was associated with worse course outcomes, lower GPA, and higher rates of withdrawal. The potential for section-level differences on potential confounding variables may have influenced the results of this study as individual randomization was not possible.

Research Question 1: Relationship Between Variables

This study demonstrated the significant negative relationship between math anxiety and mindfulness. While being low in strength, this is consistent with the relationship observed by David et al. (2021) and Weed et al. (2021). This suggests that as students increase in their present moment awareness and non-judgmental acceptance, they decrease in their anxious responding to math-related stimuli or tasks. This provides support for Hypothesis 1a, as mindfulness was negatively correlated with math anxiety.

Surprisingly, this study failed to find a significant positive relationship between mindfulness and any of the math performance variables. This was surprising considering the research suggesting mindfulness positively predicts math performance (Bellinger et al., 2015) and the positive relationship between self-awareness and math performance as well as numerical ability (Khasawneh et al., 2021). Like Bellinger et al. (2015), there was a positive relationship between mindfulness and exam scores and homework scores, but not quiz scores; however, in this study these relationships did not reach significance. This suggests there could be mediating variables at play that were not evaluated in this study, which is supported by prior research as with the finding that mindfulness positively predicts academic outcomes, mediated by compassion and engagement (Miralles-Armenteros et al., 2019). Thus, Hypothesis 1b was not supported as there was no significant correlation between mindfulness and any measure of math performance.

The relationship between math anxiety and the math performance variables is consistent with the differing stakes of the assignments. Math anxiety did not correlate with homework grades, which would be considered low-stakes assignments such as Bellinger et al. (2015). They were not high point values and could be completed at any time prior to the due date with the aid

of the textbook and notes. Math anxiety negatively correlated with quiz grades, which almost reached significance (p=.058). Quiz grades can be conceptualized as moderate-stakes assignments. They were not high point value, but they were completed in class without textbook or notes. Additionally, math anxiety significantly negatively correlated with exam grades, which would be high-stakes assignments. The exams were higher point value and completed in class without textbook or notes. This highlights how higher-stakes assignments are more impacted by math anxiety, which is consistent with research that anxiety contributes to "choking" in more high-pressure situations (i.e., Beilock, 2008). The strength of the correlation between math anxiety and exam scores was low to moderate, which is consistent with the relationships observed in correlational studies on explicit self-report assessments of math anxiety and timed math achievements tests (Westfall et al., 2021). Math anxiety negatively correlated with overall final grade, which is consistent with the pattern reported in several meta-analyses (i.e., Caviola et al., 2021; Finell et al., 2021). Thus, the findings provide partial support for Hypothesis 1c as math anxiety significantly negatively correlated with exam performance and final grade; however, its negative correlation with quiz performance was insignificant. Additionally, these findings support Hypothesis 1d as math anxiety did not correlate with homework grades.

The findings on the relationship between variables are further supplemented by the qualitative results of the pre-test interviews. Participants perceived a cyclical relationship such that mindfulness impacted their math anxiety, which impacted their preparedness. Moreover, all three of these factors were perceived as contributing to course outcomes. This supports how there may be variables mediating mindfulness' relationship with course outcomes and how math anxiety was perceived as influential on their mindfulness and course outcomes.

The age of the participants had a significant relationship with math anxiety, exam grades, and final grade. Students that were older were more likely to have higher math anxiety, worse exam performance, and worse final grade. As degree completion at this university is not a predetermined path, it is possible that students with higher math anxiety procrastinate taking the course and thus are older when they enroll. This would be supported by the impact of math anxiety on enrollment behaviors (Ramirez et al., 2018). However, other studies have had mixed results. Rozgonjuk et al. (2020) found that older students had higher math anxiety, but only for STEM students, not students in the social sciences. However, Darrani and Tariq (2009) found that math anxiety did not significantly relate to age, but numerical competence did. Specifically, older students had lower confidence and competence towards math. Moreover, this confidence and competence significantly negatively related with their math anxiety (Darrani & Tariq, 2009). This study suggests that students with high levels of math anxiety and low levels of math ability may procrastinate enrolling in statistics courses. However, this should be interpreted with caution as the participants were primarily 18-20 years old, with very few students above the age of 23.

Another demographic correlate of interest was gender, as female students had significantly higher performance on their homework, quizzes, and final grade. Females had slightly higher math anxiety, but the correlation did not reach is significance. Prior studies have suggested that women have higher math anxiety, which subsequently contributes to gender differences in math performance (i.e., Luttenberger et al., 2018; Rozgonjuk et al., 2020). However, this study does not support gender differences in math anxiety. Moreover, this study found that the women in the sample generally outperformed the men, which stands in contrast with the research of Darrani and Tariq (2009) and Hart and Ganley (2019), which suggested lower numerical fluency and math-related competencies in women. As less than a quarter of the

current sample was men, it is difficult to draw conclusions regarding gender differences in the variables. However, it does suggest that the relationship between gender and math anxiety and math performance warrants further investigation.

Research Question 2: Emotional Impact of the Intervention

Impact on Mindfulness

At the beginning of the semester, the control group had significantly higher mindfulness compared to the intervention group, with a moderate effect. However, the control group decreased over the course of the semester such that between-group differences were insignificant at Time 2 and Time 3. This decrease was significant, with a small effect, corresponding to a four percent decrease in mindfulness over the semester. In contrast, the intervention group did not have any significant changes over the semester. This is similar to the findings of Lampe and Müller-Hilke (2021), who observed sustained mindfulness in their intervention group while their control group significantly decreased from their first assessment to final assessment one year later. Their intervention was more intensive than the current study, as they included 12 hours of coursework based on Mindfulness-Based Stress Reduction.

As the MAAS assesses trait mindfulness, it is considered more stable than state mindfulness. Mahmood et al. (2016) found that five minutes of mindfulness meditation delivered online facilitated an increase in state mindfulness compared to a control group. Thus, it is probable that repeated exposure to brief mindfulness practices provide consistent boosts in state mindfulness which can benefit trait mindfulness over time. However, whether this results in lasting benefits for the students is still unclear as there were no long-term follow-up assessments after the intervention ended.

Prior studies that found mindfulness interventions can increase trait levels of mindfulness have used much more intensive interventions, such as daily mindfulness practice, which observed a moderate effect in comparison to an active control group (Vorontsova-Wenger et al., 2022). This highlights the degree of impact on participants' mindfulness is dependent on the intensity of the intervention. However, even a brief intervention is able to have a beneficial impact, helping students maintain their mindfulness. This provides support for Hypothesis 2a as participants in the intervention group sustained their mindfulness while the control group did not.

Impact on Math Anxiety

Despite starting with significantly higher math anxiety, the intervention group experienced a greater reduction in math anxiety over the course of the semester, such that differences in math anxiety between groups were insignificant by the end of the semester. The intervention group reduced by eight percent in math anxiety scores from the first assessment to the last assessment, which corresponds to a moderate effect size. The moderate effect is comparable to the reduction in math anxiety observed by the intervention group in Samuel and Warner (2021) and Samuel et al. (2022) who also used one minute of mindful breathing and five positive affirmations embedded in the classroom. A moderate effect was also observed by Brunye et al. (2013) for the impact of 15 minutes of a focused breathing exercise on math anxiety and Contreras (2020) for the impact of breathing exercises on test anxiety. Additionally, Samuel and Warner (2021) observed a large effect for reduction in math anxiety following two semesters of the intervention embedded in the classroom, which suggests cumulative benefits.

However, the control group in this study also significantly reduced in math anxiety, by four percent, which corresponds to a small effect. In contrast, the control groups in Samuel and Warner (2021) and Samuel et al. (2022) did not have significant changes from pre-test to post-

test. One potential reason for the reduction in this study is the cognitive deficit theory, which suggests deficiencies in math skills contribute to math anxiety (Korem et al., 2022). This would suggest that if individuals can enhance their math skills, they can potentially mitigate their math anxiety. This is consistent with cognitive approaches to reducing math anxiety, such as Supekar et al.'s (2015) study which found that a tutoring program geared towards improving math ability resulted in significant reductions in math anxiety. However, Supekar et al. (2015) observed a large effect for the reduction of math anxiety in contrast with the small effect observed in the current study. This is consistent with the differential intensity of the tutoring program in contrast with traditional classroom structure.

As this intervention is administered at the group level, not all participants in the intervention group may have engaged in the practices throughout the semester, despite participating in the surveys, which may weaken the direct impact of the intervention. Self-reported engagement in the intervention significantly correlated with reduction in math anxiety such that participants who reported being more engaged in the intervention were more likely to reduce in their math anxiety from Time 1 to Time 3. This suggests that the degree to which students invest in the intervention impacts the benefits they garner from it. As this type of mindfulness intervention is minimal risk and students do not have to engage in it, embedding the intervention into the classroom enables students who are interested in it to self-select to participate in the intervention which can enhance their psychological outcomes.

The greater reduction in math anxiety for the intervention group compared to the control group suggests that the mindfulness and growth mindset intervention potentially complements the benefits of an increase in skills to further benefit students' psychological outcomes. As the two groups started the semester with significant differences, the intervention group reduced in

their math anxiety to where differences were insignificant by the end of the semester, which supports a greater reduction for the intervention group compared to the control group, providing partial support for Hypothesis 2b. However, as the differences in changes over the semester were statistically insignificant, this suggestion is qualified by the need for further investigation and replication.

Research Question 3: Academic Impact of the Intervention

Many studies that investigate the impact of mindfulness or socioemotional interventions on academic outcomes only investigate the impact on exams (e.g., Lampe & Müller-Hilke, 2021; Vorontsova-Wenger et al., 2022) or final grade (e.g., Schonert-Reichl et al., 2015). Very little research has investigated the differential impact of an intervention on homework, quiz, and exam grades. While PSYC 354 and PSYC 355 had different assignments, all assignments that were classified as homework were relatively low points, open-notes, open-book, and able to be completed outside the class at any time prior to the due date, which would capture the low-stakes assignments. Assignments that were quizzes were relatively low points; however, they were completed in class without the aid of notes or textbooks, making them more moderate-stakes assignments. For both classes, exams were high-point value (comprising at least 10% of their grade), cumulative, and completed without the aid of notes or textbooks, making the exams more high-stakes assignments comparatively.

Impact on Homework

The intervention group had lower grades on homework compared to the control group, with small to moderate effects at all three time points. Both groups experienced an insignificant increase from Time 1 to Time 3. This is consistent with the original hypothesis, that the intervention would not have an impact on homework grades because of the low stakes of the

situation. While there were differences between assignments in PSYC 354 and PSYC 355, in all classes, the homework assignments are open-notes and open-book, able to be completed outside of class at any time prior to the due date, which suggests they are not very high stakes. The categorization of homework assignments as low stakes is supported by the lack of any correlation between math anxiety and homework performance. A correlational study found that mindfulness indirectly enhanced math performance through the mediation of anxiety, but only for assignments that were high stakes, such as exams or quizzes (Bellinger et al., 2015). In contrast, low-stakes assignments like homework grades were not impacted by mindfulness. While their research was correlational, it suggests that a mindfulness intervention would not benefit homework performance. This is consistent with the findings in the current study, which provides support for Hypothesis 2a.

Impact on Quizzes

At the beginning of the semester, the intervention group had significantly lower quiz grades compared to the control group, with small to moderate effects. However, the control group experienced a significant decrease in quiz grades throughout the semester, whereas the intervention group had insignificant changes. Subsequently, at Time 2 and Time 3, there were no significant differences between the two groups in quiz grades. By the end of the semester, when controlling for demographic factors and Time 1 levels of math anxiety and mindfulness, the intervention group slightly outperformed the control group. This suggests that the affective impact of the intervention translated to benefits for the intervention group on moderate stress assignments. This is consistent with findings by Bellinger et al. (2015), that the emotional impact of mindfulness on state anxiety enhanced performance on quiz grades.

The cumulative impact of mindfulness meditations on quizzes is highlighted in research by Lin and Mai (2018). They utilized 10 to 20 minutes of mindful breathing and self-awareness exercises prior to lectures. Their intervention group had significantly higher quiz performance than the control group, but only after a few weeks of consistent practice of mindfulness in the classroom (Lin & Mai, 2018). The greater intensity of their intervention could explain why they had more drastic impacts on quiz performance compared to the current study. Similarly, Brunye et al. (2013) found that a focused breathing exercise contributed to greater accuracy on higher difficulty assignments for individuals with high math anxiety. This suggests that the mindful breathing that the intervention group participated in, could have facilitated greater accuracy for the quizzes, which provides support for Hypothesis 3b, as the participants in the intervention group had enhanced quiz outcomes compared to the control group.

Impact on Exams

The intervention group had significantly lower performance than the control group across all three exams, with small effect sizes. Both groups demonstrated an insignificant increase from Exam 1 to Exam 3. This suggests that the intervention did not have an impact on exam grades. This was surprising considering Bellinger et al.'s (2015) research that mindfulness predicted reductions in state anxiety that facilitated enhanced performance on exams. However, their research is correlational which does not support causality within the relationship. More intensive mindfulness interventions have contributed to significant improvements in exam grades compared to a control group, with large effects (e.g., Anila & Dhanalakshmi, 2017; Vorontsova-Wenger et al., 2022), which is not consistent with the current study. The findings in the current study are consistent with research which found that 20-minute mindfulness meditations embedded in the classroom had benefits for quiz grades, but not cumulative assessments such as

exams (Lin & Mai, 2018). Similarly, Samuel et al. (2022) did not find any differences in final exam performance between the intervention group and control group. This provides further support that the effect of mindfulness interventions of academic outcomes is dependent on the dose of mindfulness. While mindfulness interventions have the potential to enhance exam grades, they need to be more intensive to do so. In contrast, the low intensity of the current intervention was not sufficient to facilitate any impact on exam grades. This fails to provide support for Hypothesis 3c as the intervention did not benefit students' exams grade compared to the control group.

Final Grade

For both PSYC 354 and PSYC 355, final grade was determined by the cumulative performance on homework, quizzes, and exams. While an independent samples t-test suggested that the intervention group performed significantly lower overall, when controlling for demographic factors and Time 1 levels of math anxiety and mindfulness, these differences are insignificant. This suggests that the impact of lower performance across exams and homework was mitigated by the improvements in quiz grades in the intervention group. Despite the interventions group's significantly disparate starting point, they were able to perform comparably to the control group because of the intervention. This coincides with research that mindfulness training can enhance overall academic performance (e.g., Sampl et al., 2017; Schonert-Reichl et al., 2015) and suggests that for low-intensity interventions, the mechanism by which it impacts academic performance overall is through improvements in moderate-stress assignments, such as quizzes.

Research Question 4: Impact of Intervention on Student Experiences

Pretest Thematic Analysis

The thematic analysis of pretest semi-structured interviews highlighted how students perceive mindfulness, math anxiety, and success in the course. Students recognized the complexity of mindfulness with its affective and cognitive components that translate to affective and cognitive impacts. Students similarly perceived math anxiety as multifaceted, influenced by their competence, beliefs, and environment. Moreover, math anxiety was perceived as having a multifaceted impact, affecting their thoughts, physical reactions, and behaviors. Their perception brought to light how multiple factors can impact their success in the course. They perceived their professors, and the classroom as a whole, as key external factors contributing to course outcomes. Additionally, internal factors such as their effort, ability, and beliefs were perceived as influencing their success. Throughout the transcripts, there was a perception of the cyclical interrelationship between mindfulness, math anxiety, and engagement, which subsequently impacted course outcomes.

Understanding of Mindfulness

Participants perceived mindfulness as becoming effortfully aware of one's thoughts and feelings. This coincides with a narrative review of how college students perceive mindfulness, which similarly reported the relationship between mindfulness and awareness (Bamber & Schneider, 2020). Participants viewed mindfulness as involving reflection, without judgment, on their cognitions, emotions, and experiences. This is consistent with research on teachers' experiences with mindfulness, in which they reported mindfulness as taking time to slow themselves down, which enabled them to have better awareness and involvement in the classroom (Mackenzie et al., 2020). By giving themselves time to reflect, they felt cognitive

benefits of mindfulness as it helped their mental focus. Enhanced focus is a recurrent theme across qualitative investigations into mindfulness (Bamber & Schneider, 2020; Crowther et al., 2020). Additionally, students in the current study perceived an emotional benefit of mindfulness, enabling emotion regulation and management of anxiety. This coincides with their quantitative results as well, with the negative relationship between math anxiety and mindfulness. Similarly, other qualitative studies have highlighted the importance of mindfulness for stress management and emotion regulation (Bamber & Schneider, 2020; Monshat et al., 2013).

Understanding of Math Anxiety

In the current study, participants viewed math anxiety as connected to their competence in math. In addition to actual ability, it was related to perceived ability and self-efficacy. This coincides with teachers' perspectives that lacking self-confidence was an antecedent to math anxiety in the classroom (Finlayson, 2014). A qualitative case study also emphasized the impact of doubts and beliefs on their math anxiety and experiences with math (Stoehr, 2017). The present study also highlighted perception of the statistics classroom as elevating their anxiety, which draws attention to the situational reactivity of math anxiety. This bolsters the findings of Finlayson (2014), who reported that many of the contributing factors to math anxiety are related to the classroom environment.

Math anxiety had a perceived physiological impact, contributing to headaches and nervous scratching. These are distinct from the physiological symptoms of math anxiety identified by Finlayson (2014), which included irregular respiratory rate, elevated heart rate, nausea, sweating, and biting nails. This suggests math anxiety's physical impact on students can vary. Prior research has suggested that math anxiety can have a behavioral impact, contributing to avoidant responses (e.g., Richardson & Suinn, 1972), which is supported by the current

study's finding that math anxiety can impact enrollment decisions and procrastination. Students perceived math anxiety as constraining their classroom engagement and mindfulness, which subsequently worsened outcomes. This is further supported by qualitative research which has found math anxiety contributed to shutting down and not listening to the teacher because they are overwhelmed by the anxiety (Finlayson, 2014). Students also perceived that math anxiety made learning more difficult. Other research has also suggested math anxiety contributes to confusion and frustration, which could explain why math anxiety makes learning difficult (Finlayson, 2014).

Contributors to Success

In describing factors perceived as important to their success, students repeatedly noted the importance of the professor. They viewed the professor as a resource, someone who was there to help them succeed. Previous research has suggested that students perceive the professor for a course as impacting how students approach learning (Markle, 2017). Additionally, the current study found students perceived the professor as responsible for the emotional environment of the classroom, shaping engagement and confidence, which impacted course success. The impact of the professor on the socioemotional climate of the classroom is supported by Mackenzie et al. (2020), who emphasized that teachers are essential for the culture of the class. The classroom context was also perceived as influential. Being in a classroom enabled access to a supportive community of classmates, which provided for collaboration. This is consistent with quantitative findings that emphasize the relationship between the classroom's emotional and relational climate and academic outcomes (Amutio et al., 2022; Cahyadi et al., 2021). Additionally, they perceived their fellow students as possible resources that could help them when faced with challenges.

In addition to external factors, students emphasized internal characteristics as crucial to success. Students perceived statistics as a course that required significant effort and motivation. This sheds light onto Lisciandro et al.'s (2018) finding of the importance of enjoyment and interest for academic outcomes in math courses. Students who enjoy the content and are interested in it will be more motivated to put in the effort required of a difficult math-related course. Students also emphasized the importance of seeing the purpose of statistics. This coincides with research by Markle (2017) which found that students in research methods courses emphasized that beliefs about the utility of the course were crucial to their outcomes. Students also emphasized how negative self-talk and beliefs about their ability influenced their effort and course outcomes. This is comparable to findings that emphasize the impact of one's self-concept and anxiety towards math (Markle, 2017).

Students perceived a complex interrelationship between the variables as mindfulness and math anxiety had a bidirectional relationship. Additionally, mindfulness contributed to their preparedness and engagement, which influenced the extent of their anxiety in the course. These factors were subsequently perceived as contributing to their course success. As prior qualitative investigations have generally emphasized one topic, such as experiences with mindfulness (e.g., Mackenzie et al., 2020), experiences with math anxiety (e.g., Stoehr, 2017), or perceptions of learners in math-related courses (e.g., Lisciandro et al., 2018), this study enables greater synthesis of the previous research, providing a more complete perspective of how students perceive the cyclical relationship between mindfulness, math anxiety, and course outcomes.

Posttest Thematic Analysis

The posttest transcripts from the intervention group provided key insight into the students' perception and experience with the intervention. Students perceived the intervention as

calming the classroom, benefiting their emotions and bringing a sense of relief. A calm start for the class was also noted by qualitative focus groups in previous research regarding experience with classroom-based mindfulness (Samuel & Warner, 2021). Specifically, the breathing exercises were emphasized as reducing anxiety, which coincides with Samuel and Warner (2021) and Samuel et al. (2022), who found students perceived reduced math test anxiety due to the mindful deep breathing. In the current study, the breathing exercises were also noted as getting students in the mindset to learn while the affirmations enhanced their focus. In contrast, Samuel et al. (2022) reported that students perceived the positive affirmations as building their confidence, not necessarily their focus. However, it is possible that increases in confidence enable students to focus better. Additionally, improvements in focus were noted by a narrative review of mindfulness interventions on college students (Bamber & Schneider, 2020).

The intervention impacted the class as a whole and was perceived as preparing the whole class to be engaged in the content. Other studies have noted mindfulness practices at the beginning of class are perceived as benefiting the learning experience (Mapel, 2012) and enabling participants to be ready for class (Tufford, 2019). Additionally, students' perception of the intervention shifted over the semester, with confusion or lack of interest at the beginning, which transitioned to being engaged in the intervention, which contributed to better engagement in the class. A similar pattern of shifting engagement in the intervention was also noted in the transcripts by Samuel et al. (2022). This highlights how students do not necessarily see the benefits of the intervention early in the semester, however, the benefits accumulate as students increasingly become involved in the intervention.

Another finding was the students perceived the professor as playing an important role with the intervention, which enabled them to see the professor believed that they could do it.

This is congruent with Samuel and Warner's (2021) research as well, which found the instructor's facilitation of the intervention to be a crucial component to its success. It is critical to note that the professor's facilitation was still noted for the current study, despite using video-based breathing exercises in contrast with professor-led breathing exercises used by Samuel and Warner (2021). This suggests that the video-based breathing was still able to convey the professor's belief in the students, which was perceived as important to the intervention's effectiveness. Participants in the interviews perceived the intervention positively; however, they recognized distraction and disinterest were potential barriers for the effectiveness of the intervention. Distractions from other students who were not engaging in the intervention was described as a challenge to mindfulness (Tufford, 2019). Lack of effort in the mindfulness-based programs was also noted as a barrier in previous research (Bamber & Schneider, 2020). Prior studies have also emphasized the time constraints as a barrier to mindfulness (e.g., Bamber & Schneider, 2020; Bultas et al., 2021), which was mitigated by the minimal time required for the current intervention.

Posttest Thematic Comparison

While numerous studies have investigated the experiential impact of mindfulness-based interventions by conducting qualitative research with participants in the intervention, few studies conduct qualitative investigations with both participants from the intervention and control group, which was noted as a critical gap according to a recent qualitative scoping review (Crowther et al., 2020). By evaluating not only how participants perceived the intervention, but how their perceived experience differs from the control group, thematic comparison is able to provide deeper insight into the impact of the intervention on student experiences in the classroom.

In comparing transcripts between the two groups, participants from the intervention group reported perceiving an increase in mindfulness over the course of the semester. In contrast, the control group emphasized wishing the classroom promoted mindfulness more, perceiving that it could have benefited their outcomes. The reported growth in the intervention group is supported by other studies that have drawn attention to the impact of mindfulness interventions on perceived self-awareness of participants (e.g., Bamber & Schneider, 2020; Mackenzie et al., 2020). The need for socioemotional elements of the classroom to be addressed was emphasized by a qualitative inquiry into students' perceptions going into college (Lisciandro et al., 2018). This highlights how students perceive a need in the classroom that could be mitigated by embedded interventions such as the one in the current study. Changes in math anxiety over the semester were more variable. The intervention group participants emphasized either a decrease in math anxiety or better control over their anxiety because of mindfulness. In contrast, the control group participants emphasized their anxiety increasing due to upcoming exams or feeling overwhelmed. Better emotional control and a decrease in anxiety is supported by prior studies (e.g., Bamber & Schneider, 2020; Samuel & Warner, 2021).

Participants from the intervention group expressed more positive statements towards statistics compared to the control group, despite the two groups having comparable positive perceptions of the professor and the classroom community. This suggests that the intervention helped to reframe statistics more positively and able to see its value and purpose more clearly compared to the control group. This is consistent with research suggesting that mindfulness, with its impact on self-awareness, enables greater insight into value and purpose (Bamber & Schneider, 2020; Crowther et al., 2020). In light of the pre-test transcripts and other studies (e.g., Markle, 2017), being able to see the purpose of statistics is perceived as benefiting course

outcomes. The current study bolsters the findings of previous by highlighting that the improvements in mindfulness, emotional regulation, and seeing the overarching purpose are not observed in control groups. This suggests this impact is due to the mindfulness interventions rather than just natural maturation over the semester.

Exploratory Analyses

Impact of Intervention on At-Risk Students

Further exploration of the impact of the intervention brought to light potential benefits for students who are at-risk for performing poorly in the class. These findings may be influenced by the cut-off chosen to define "at-risk." Prior studies have defined risk based on sociodemographic characteristics (e.g., Andreu et al., 2021). However, the homogeneity of the current sample limited that as an option. Other studies have used standard deviations of pretest academic performance to determine lower performers (e.g., Porter et al., 2022). While the current study considered using one full standard deviation, that resulted in zero participants from the control group, which would prevent any meaningful comparison. Thus, performing at one-half a standard deviation below the mean or lower was chosen as the cut-off to provide a large enough sample to investigate trends while still focusing on students who were really struggling in the class at the beginning of the semester.

The students who were categorized as "at-risk" in the intervention group had significantly lower mindfulness at Time 1, which is consistent with the pattern of low mindfulness in the intervention group observed in the sample as a whole. Despite lower quiz and exam grades at Time 1, the intervention group outperformed the control group on Quiz 2, Quiz 3, Exam 3, and in overall final grade with large effect sizes. Similarly, the effect size was large for differences in percent change from Quiz 1 to Quiz 3 and Exam 1 to Exam 3. While inferential statistics is

limited for such a small sample of only seven students, the large effect sizes observed suggest that the differential impact of the intervention on at-risk students merits further investigation. The enhanced benefit for individuals who are at-risk is further supported by studies of Yeager et al. (2019) and Porter et al. (2022), in which growth mindset interventions embedded in the classroom had the greatest impact on academic achievement for low-performing students. While their intervention was more time intensive compared to the current study, these findings suggest that even a less intensive intervention may be sufficient to address some of the challenges faced by at-risk students. Similarly, mindfulness interventions have also demonstrated mitigating decrements in performance, such as caused by anxiety or stereotype threat (Weger et al., 2012).

Exploration of Class Differences

The exploratory analyses for class differences highlight the comparable trends observed between PSYC 354 and PSYC 355, which supported the decision to consolidate the separate sections into a “control group” and “intervention group” to boost sample size. However, these classes did have differences in their schedule, content, and style of homework, quiz, and exam assignments. The PSYC 354 classes met three times a week. The control section met from 12 to 12:50pm while the intervention section met from 1:05-1:55pm. However, the PSYC 355 classes only met twice a week and for a longer duration. The control section met from 11:15-12:30 while the intervention section met from 12:45-2pm. They also differed in their content as PSYC 355 builds off the content covered in PSYC 354. PSYC 354 introduces students to concepts of descriptive statistics, probability distributions, hypothesis testing, and visualization of data. In contrast, PSYC 355 introduces more complicated statistical testing and interpretation of psychological data from distinct research designs. Additionally, the number and value of the different homework assignments, quizzes, and exams may have influenced outcomes. These

differences in course structure may explain their significant differences for homework and quiz grades. These differences are mitigated by the decision to randomly assign one section from PSYC 354 and one section from PSYC 355 to the intervention group, with the remaining sections assigned to control. This enabled more balanced investigation into the impact of the intervention regardless of the course or teacher.

Implications

The findings of this study have implications for the understanding of math anxiety and its impacts. The qualitative findings shed light on math anxiety's perceived behavioral, physiological, and cognitive impact. Definitions of math anxiety should ensure including these components to reflect a more accurate understanding of the condition. This research also informs gender differences in anxiety towards math. In the current sample, women did not have higher math anxiety than men, which adds to the variability in the literature on gender's impact on math anxiety (Khasawneh et al., 2021). Moreover, women actually outperformed men on their homework and quizzes, but not exams. This would suggest that in the absence of higher math anxiety, there is variability as to gender differences in math performance.

The findings of the current study also draw attention to the differential relationship between math anxiety and math performance depending on the performance outcome being assessed. The increasing correlational strength between math anxiety and homework, quizzes, and exams, coincides with the pressures of those assignments, highlighting that math anxiety is sensitive to the situational stakes (Brunye et al., 2013). This research also suggests that studies that only focus on final grade or final exams may not be addressing the full picture of math anxiety's impact on math achievement. While this study cannot definitively address whether math anxiety causes worse math achievement or vice versa, the qualitative research suggests

students perceive them as having a cyclical relationship as competence impacts math anxiety which impacts performance.

This study also carries important implications for preventative and interventive measures to reduce math anxiety in the classroom. It highlights that math anxiety is a critical issue especially for psychology undergraduate students, who have demonstrated higher levels of math anxiety than other samples (e.g., O'Leary et al., 2017), which is supported by the current study. The findings suggest that increases in math skills as well as socioemotional interventions can have a significant impact on math anxiety. As math anxiety is a global challenge for education that is observed across grades and negatively impacts math achievement, it is critical to evaluate how to mitigate its impact (Barroso et al., 2021; Foley et al., 2017). This study suggests that mindfulness-based interventions may be effective for ameliorating math anxiety for undergraduate students. Additionally, as the qualitative findings suggest, even in the absence of a decrease in math anxiety, an increase in mindfulness can help students manage their math anxiety. With the simplicity of the intervention, it could easily be adapted to other grade levels to address this widespread pedagogical issue. The ability to target math anxiety is critical because of its deleterious impact on math performance and phobia-like impact on behaviors, which can constrain an individual's academic and vocational decisions (Richardson & Suinn, 1972; Rozgonjuk et al., 2020).

While math anxiety is distinct from other kinds of anxiety-related conditions, interventions that can effectively address math anxiety could be applicable to other academically-stressful scenarios and potentially mitigate other anxieties as well (Hart & Ganley, 2019). In the context of the classroom, utilizing mindfulness-based interventions to target test anxiety or other domain-specific anxieties, could be effective. Additionally, prior studies have

suggested that mindfulness can be adapted outside of the classroom to address the deleterious impact of generalized anxiety as well (Vorontsova-Wenger et al., 2022).

This research also has implications for utilization of mindfulness and growth mindset interventions in the classroom. While previous research has generally neglected evaluating whether mindfulness-based interventions actually impact participants' mindfulness (as noted by Creswell, 2017), this study draws attention to the beneficial impact of a brief mindfulness and growth mindset intervention on students' mindfulness, helping them maintain their mindfulness over the semester. Given the connection of mindfulness to mental well-being, perceived stress, anxiety, working memory ability, and academic performance, identifying interventions that benefit mindfulness could facilitate additional academic, emotional, and cognitive benefits for the recipients (Bellinger et al., 2015; Lampe & Müller-Hilke, 2021; Li et al., 2021; Miralles-Armenteros et al., 2019).

This research also supports the adaptability of mindfulness. While mindfulness-based interventions can be quite intensive, previous studies have highlighted that students dislike interventions that require too much of their time (e.g., Bultas et al., 2021). In contrast, this study highlights that a brief mindfulness intervention can be adapted to the needs of the classroom, taking less than two minutes of class time each period. Additionally, as it was primarily video-based it was successfully and easily implemented by two different professors who had not received prior mindfulness training, which suggests mindfulness can be adapted to be an educational resource that instructors can implement in their classrooms. The video-based breathing exercises enabled reduced burden on the faculty, whereas previous studies had faculty members complete additional training to learn how to lead breathing exercises on their own (Samuel & Warner, 2021). This intervention still translated to emotional and academic benefits

for the students with minimal faculty time burden, which highlights its versatility and utility as a pedagogical resource.

This research also has implications for the value of applying the same rigorous design that is desired of quantitative research to qualitative research. Mixed methods studies that evaluate the impact of interventions generally conduct qualitative investigation with only the intervention group and only posttest (e.g., Samuel & Warner, 2021). In contrast, rigorous quantitative designs typically include pretest and posttest as well as comparison with a control group. In applying this rigor in the current study, it enabled deeper understanding of the participants' initial understanding of math anxiety, mindfulness, and what contributes to their success in the course at the beginning of the semester. Additionally, by interviewing both the control group and the intervention group at the beginning and end of the semester, this enabled their unique experiences and perceptions of change over the semester to be contrasted both within subjects and between subjects. This study provided evidence that thematic analysis in addition to thematic comparison can yield valuable insight into the experiential impact of an intervention.

Limitations and Directions for Future Research

While this study had many strengths, there are some notable limitations. Firstly, the small sample size resulted in many of the complex analyses being underpowered. While more powerful analyses enabled exploration of the impact, this may have elevated risk of Type 1 error (Warner, 2021). Constraints relating to sample size motivated the decision to consolidate PSYC 354 and PSYC 355 sections into combined "groups" for analyses, which is a limitation because the courses are not equivalent. While both are statistics classes that are required for psychology undergraduates, PSYC 354 precedes PSYC 355 and the content they cover is distinct. Moreover,

for the qualitative research, only a total of 10 students volunteered to participate, which may reflect a self-selection bias and may not be representative of the classroom as a whole. Future research should expand the intervention to a larger sample and explore how the intervention may impact different types of classes in different ways. Additionally, recruiting participants for the qualitative investigation at random could further strengthen the thematic outcomes.

Another sampling limitation, in addition to its size, was its relative homogeneity. The sample was primarily white, female psychology undergraduate students from one university in the southeastern United States. This limits generalizability to other demographics, academic disciplines, and geographic locations. As the study was embedded in a real-world context of the classroom, that suggests it could generalize to other classrooms, however, further exploration with a more diverse sample is necessary to evaluate the extent of generalizability.

Thirdly, this study was quasi-experimental and not experimental. Due to the nature of the intervention being embedded in the classroom, it was not possible to randomly assign students to intervention or control. Rather, randomization had to take place at the level of the classroom. As students are self-selecting to different sections, it is possible that section-level differences had an influence on student outcomes, especially regarding motivation and prior ability (Freer-Weiss, 2004). While this study did evaluate some confounding variables, it is beyond the scope of this study to evaluate other potentially influential confounds such as self-efficacy, prior math experience, or working memory capacity (Carpenter & Kirk, 2017; Mattarella-Micke et al., 2011; Moustafa et al., 2021). Future studies should pursue greater experimental control with randomized controlled trials to mitigate these confounds.

Fourthly, because the intervention was administered at the group level and some participants reported low levels of engagement with the intervention, the disengaged students

would not have received the same benefits as students with higher levels of engagement, potentially diluting the intervention's effect. However, it is difficult to disentangle individual-level differences with a group-level intervention. While this study assessed self-reported engagement in the intervention at the end of the semester, this is limited by social desirability bias as well as recall bias. Future studies should more closely evaluate individual engagement with the intervention to determine its impact on academic and psychological outcomes.

Additionally, because the professors both taught a section of the intervention group and the control group, it is possible that the impact of the intervention on the faculty resulted in a spillover effect, in which elevated mindfulness and growth mindset of the faculty impacted outcomes in the control group. While having a consistent professor is also a strength because it is desired to have the standard instruction be consistent between sections, it is impossible to evaluate the extent to which the effects of the intervention may have permeated to the control group due to the influence of the professor. Future research should investigate the impact of embedded classroom interventions on the professors and their teaching styles.

Additionally, as it is not a blind study, the professors of the courses are aware of which section is the intervention and which is the control, which may have resulted in unconscious biases. Both professors are uninvolved in the current study and have no stake in its outcomes, which helps to mitigate this potential bias; however, it is impossible to rule it out completely. Future studies need to balance evaluating interventions in an embedded, real-world context with better experimental control.

In light of these limitations, this study is not conclusive and only provided preliminary support for several areas of interest that warrant further exploration. Subsequent research should replicate the influence of mindfulness and growth mindset interventions on facilitating a positive

perception of statistics. Several students in the interviews emphasized the critical importance of seeing the value of statistics for contributing to their motivation, engagement, and outcomes. If mindfulness and growth mindset interventions can enable greater perception of the purpose of statistics, this could potentially benefit students' success in the course. This study also provided preliminary support for the impact of mindfulness on moderate-stress assignments; however, future research should replicate this impact and disentangle the mechanism by which mindfulness enhances academic performance. Subsequent studies should also consider clarifying at what level of intensity can mindfulness interventions benefit performance on more high-stakes assignments, such as exams.

Conclusion

This present study was innovative in expanding on a prior mindfulness and growth mindset intervention to explore whether it impacted not only math anxiety, but also mindfulness and math performance. By building on the previous design to make the intervention video-based, the intervention placed minimal burden on faculty while still having a beneficial impact on students. This research fills the gap in the literature by evaluating an educational resource that can easily be implemented and adapted to meet the needs of different classrooms. This study specifically demonstrated a brief mindfulness and growth mindset intervention integrated into the classroom can reduce math anxiety, sustain mindfulness, and enhance performance on moderate stress assignments. Future research needs to evaluate the generalizability of mindfulness-based interventions and their impact when under more stringent experimental control. Doing so will enable educators to implement evidence-based best practices in their classrooms to address the socioemotional needs of their students and optimize academic outcomes.

References

Ahmad, F., Morr, C. E., Ritvo, P., Othman, N., Moineddin, R., & Team, M. V. C. (2020). An eight-week, web-based mindfulness virtual community intervention for students' mental health: Randomized controlled trial. *Journal of Medical Internet Research: Mental Health*, *7*(2), e15520. https://doi.org/10.2196/15520

Amutio, A., Telletxea, S., Mateos-Pérez, E., Padoan, S., & Basabe, N. (2022). Social climate in university classrooms: A mindfulness-based educational intervention. *Psych Journal*, *11*(1), 114–122. https://doi.org/10.1002/pchj.509

Andreu, C. I., Araya-Veliz, C., Garcia-Rubio, C. (2021). Benefits of a mindfulness-based intervention at school from the perspective of at-risk children. *Mindfulness, 12*(7), 1611-1623. doi:10.1007/s12671-021-01624-6

Anila, M. M., & Dhanalakshmi, D. (2016). Mindfulness based stress reduction for reducing anxiety, enhancing self-control and improving academic performance among adolescent students. *Indian Journal of Positive Psychology, 7*(4), 390-397.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

Ashcraft, M. H., & Faust, M. W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition and Emotion, 8*(2), 97-125.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology, 130*(2).

Ashkenazi, S., & Danan, Y. (2017). The role of mathematical anxiety and working memory on the performance of different types of arithmetic tasks. *Trends in Neuroscience and Education, 7*, 1-10. https://doi.org/10.1016/j.tine.2017.05.001

Baddeley, A. D., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (pp. 47-89). Academic Press.

Bamber, M. D., & Schneider, J. K. (2016). Mindfulness-based meditation to decrease stress and anxiety in college students: A narrative synthesis of the research. *Educational Research Review, 18*, 1–32. https://doi.org/10.1016/j.edurev.2015.12.004

Bamber, M. D., & Schneider, J. K. (2020). College students' perceptions of mindfulness-based interventions: A narrative review of the qualitative research. *Current Psychology, 41*(2), 667-680. https://doi.10.1007/s12144-019-00592-4

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

Beilock, S. L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science, 17*(5), 339-343. https://doi.10.1111/j.1467-8721.2008.00602.x

Bellinger, D. B., DeCaro, M. S., & Ralston, P. A. S. (2015). Mindfulness, anxiety, and high-stakes mathematics performance in the laboratory and classroom. *Consciousness and Cognition, 37*, 123-132. http://dx.doi.org/10.1016/j.concog.2015.09.001

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246–263. https://doi.org/10.1111/j.1467-8624.2007.00995.x

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2).

Brown, A. P., Marquis, A., & Guiffrida, D. A. (2013). Mindfulness-based interventions in counseling. *Journal of Counseling and Development, 91*(1). https://doi.org/10.1002/j.1556-6676.2013.00077.x

Brown, K. W., & Ryan, R. M. (2003). Mindful Attention Awareness Scale. *PsycTESTS*. https://doi.org/10.1037/t04259-000

Brunye, T. T., Mahoney, C.R., Giles, G. E., Rapp, D. N., Taylor, H. A., & Kanarak, R. B. (2013). Learning to relax: Evaluating four brief interventions for overcoming the negative emotions accompanying math anxiety. *Learning and Individual Differences*, *27*(1), 1-7. http://dx.doi.org/10.1016/j.lindif.2013.06.008

Bultas, M. W., Boyd, E., & McGroarty, C. (2021). Evaluation of a brief mindfulness intervention on examination anxiety and stress. *Journal of Nursing Education, 60*(11), 625-630. https://doi.10.3928/01484834-20210913

Cahyadi, A., Hendryadi, H., & Mappadang, A. (2021). Workplace and classroom incivility and learning engagement: The moderating role of locus of control. *International Journal for Educational Integrity, 17*(4).

Carpenter, T. P., & Kirk, R. (2017). Are psychology students getting worse at math?: Trends in the math skills of psychology statistics students across 21 years. *Educational Studies, 43*(3). https://doi.org/10.1080/03055698.2016.1277132

Caviola, S., Toffalini, E., Giofre, D., Ruiz, J. M., Szucs, D. & Mammarella, I. C. (2021). Math performance and academic anxiety forms: From sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychology Review, 34*(1).

Ching, B. H. (2017). Mathematics anxiety and working memory: Longitudinal associations with mathematical performance in Chinese children. *Contemporary Educational Psychology, 51*(1), 99-113. doi:10.1016/j.cedpsych.2017.06.006

Contreras, E. (2020). *The impact of deep breathing on test anxiety: A quantitative pre-test/post-test quasi-experimental study* [Doctoral dissertation, Northcentral University]. Proquest.

Cosme, D., & Wiens, S. (2015). Self-reported trait mindfulness and affective reactivity: A motivational approach using multiple psychophysiological measures. *PloS One, 10*(3). doi:10.1371/journal.pone.0119466

Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology, 68*, 291-516. doi:10.1146/annuarev-psych-042716-051139

Creswell, J. W., Klassen, A. C., Plano Clark, V. L., & Smith, K. C. (2011). *Best practices for mixed methods research in the health sciences*. National Institutes of Health.

Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage.

Crowther, L. L., Robertson, N., & Anderson, E. S. (2020). Mindfulness for undergraduate health and social care professional students: Findings from a qualitative scoping review using the 3P model. *Medical Education, 54*(9), 796-810. https://doi.10.1111/medu.14150

Darrani, N., & Tariq, V. (2009). Relationships between undergraduates' mathematics anxiety and their attitudes towards developing numeracy skills and perceptions of numerical competence. *Proceedings of the ICER/2009 Conference.*

David, A., Rubinsten, O., & Berkovich-Ohana, A. (2021). Math anxiety, self-centeredness, and dispositional mindfulness. *Journal of Educational Psychology, 114*(2). http://dx.doi.org/10.1037/edu0000550

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

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

Dweck, C. S. (2006). *Mindset*. Random House.

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry, 6*(4), 267–285.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition and Emotion*, *6*(6), 409–434. https://doi.org/10.1080/02699939208409696

Eysenck, M. W., & Derakshan, N. (2011). New perspectives in attentional control theory. *Personality and individual differences, 50*(7). https://doi.10.1016/j.paid.2010.08.019

Faust, M. W. (1992). *Analysis of physiological reactivity in mathematics anxiety*. [Doctoral dissertation, Bowling Green State University]. Proquest.

Finell, J., Sammallahti, E., Korhonen, J., Eklof, H., & Jonsson, B. (2021). Working memory and its mediating role on the relationship of math anxiety and math performance: A meta-analysis. *Frontiers in Psychology, 12*. https://doi.10.3389/fpsyg.2021.798090

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools*, *17*(1), 99-115. https://doi. 10.1177/1365480214521457

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. *Current Directions in Psychological Science, 26*(1), 52-58. https://doi.10.1177/0963721416672463

Freer-Weiss, D. (2004). Community college freshman: Last in, first out? *Journal of College Student Retention, 6*(2), 137-154.

Georges, C., Hoffmann, D., & Schiltz, C. (2016). How math anxiety relates to number-space associations. *Frontiers in Psychology, 7*. https://doi.10.3389/fpsyg.2016.01401

Hale, J. M., & Bray, N. J. (2011). The impact of registration timing on student performance. *Community College Journal of Research and Practice, 35*(7), 556-573. doi:10.1080/10668920802289984

Hart, S., & Ganley, C. (2019). The nature of math anxiety in adults: Prevalence and correlates. *Journal of Numerical Cognition*, *5*, 122–139. https://doi.org/10.5964/jnc.v5i2.195

Havlicek, L. L., & Peterson, N. L. (1974). Robustness of the *t* test: A guide for researchers on effect of violations of assumptions. *Psychological Reports, 34*(3).

Headspace. (2018, November 2). *Mini meditation: Breathe* [Video]. YouTube. https://www.youtube.com/watch?v=cEqZthCaMpo

Henderson, R. K., Snyder, H. R., Gupta, T., & Banich, M. T. (2012). When does stress help or harm? The effects of stress controllability and subjective stress response on Stroop performance. *Frontiers in Psychology*, *3*, 179. https://doi.org/10.3389/fpsyg.2012.00179

Hofmann, S. G., & Gómez, A. F. (2017). Mindfulness-based interventions for anxiety and depression. *Psychiatric Clinics, 40*(4), 739–749. https://doi.org/10.1016/j.psc.2017.08.008

Hopkins, C. R., Hoyle, R. H., & Gottfredson, N. C. (2015). Maximizing the yield of small samples in prevention research: A review of general strategies and best practices. *Prevention Science, 16*(7), 950-955. doi:10.1007/s11121-014-0542-7

Hopko, D. R., Ashcraft, M. H., Gute, J., Ruggiero, K. J., & Lewis, C. (1998). Mathematics anxiety and working memory: Support for the existence of a deficient inhibition mechanism. *Journal of Anxiety Disorders, 12*(4).

Jamieson, J. P., Peters, B. J., Greenwood, E. J., & Altose, A. J. (2016). Reappraising stress arousal improves performance and reduces evaluation anxiety in classroom exam situations. *Social Psychological and Personality Science*, *7*(6), 579–587. https://doi.org/10.1177/1948550616644656

Jha, A. P., Denkova, E., Zanesco, A. P., Witkin, J. E., Rooks, J., & Rogers, S. L. (2019). Does mindfulness training help working memory 'work' better? *Current Opinion in Psychology*, *28*, 273–278. https://doi.org/10.1016/j.copsyc.2019.02.012

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion, 10*(1), 54–64. https://doi.org/10.1037/a0018438

Justicio-Galiano, M.-J., Martin-Puga, M. E., Linares, R., & Pelegrina, S. (2017). Math anxiety and math performance in children: The mediating roles of working memory and math self-concept. *British Journal of Educational Psychology*, *87*(4).

Justicio-Galiano, M.-J., Pelegrina, S., Lechuga, M.-T., Gutierrez-Palma, N., Martina-Puga, E.-M., & Lendinez, C. (2016). Math anxiety and its relationship to inhibitory abilities and perceived emotional intelligence. *Anales de Psicologia*, *32*(1), 125-131. http://dx.doi.org/10.6018/analesps.32.1.194891

Kabat-Zinn, J. (2005). *Coming to our senses: Healing ourselves and the world through mindfulness.* Hyperion.

Kabat-Zinn, J. (2012). *Mindfulness for beginners*. Sounds True.

Kabat-Zinn, J. (2015). Mindfulness. *Mindfulness, 6*(6), 1481–1483. https://doi.org/10.1007/s12671-015-0456-x

Kenwright, D., McLaughlin, T., & Hansen, S. (2021). Teachers' perspectives about mindfulness programmes in primary schools to support wellbeing and positive behaviour. *International Journal of Inclusive Education.* https://doi.10.1080/13603116.2020.1867382

Khasawneh, E., Gosling, C., & Williams, B. (2021). What impact does maths anxiety have on university students? *BioMedCentral Psychology, 9*(37), 1-9. https://doi.org/10.1186/s40359-021-00537-2

Klados, M. A., Simos, P., Micheloyannis, S., Margulies, D., & Barmidis, P. D. (2015). ERP measures of math anxiety: How math anxiety affects working memory and mental calculation tasks? *Frontiers in Behavioral Neuroscience, 9*. doi:10.3389/fnbeh.2015.00282

Korem, N., Cohen, L. D., & Rubinsten, O. (2022). The link between math anxiety and performance does not depend on working memory: A network analysis study. *Consciousness and Cognition, 100*. https://doi.10.1016/j.concog.2022.103298

LaGue, A., Eakin, G., & Dykeman, C. (2019). The impact of mindfulness-based cognitive therapy on math anxiety in adolescents. *Preventing school failure: Alternative education for children and youth, 63*(2), 142-148. https://doi.org/10.1080/1045988X.2018.1528966

Lampe, L. C., & Müller-Hilke, B. (2021). Mindfulness-based intervention helps preclinical medical students to contain stress, maintain mindfulness, and improve academic success. *BMC Medical Education, 21*. https://doi:10.1186/s12909-021-02578-y

Lau, N. T. T., Hawes, Z., Tremblay, P., & Ansari, D. (2022). Disentangling the individual and contextual effects of math anxiety: A global perspective. *Proceedings of the National Academy of Sciences, 119*(7), e2115855119. https://doi.org/10.1073/pnas.2115855119

Leys, C., Delacre, M., Mora, Y. L., Lakens, D., & Ley, C. (2019). How to classify, detect, and manage univariate and multivariate outliers and pre-registration. *International Review of Social Psychology, 32*(1). http://doi.org/10.5334/irsp.289

Lin, J. W., & Mai, L. J. (2018). Impact of mindfulness meditation intervention on academic performance. *Innovations in Education and Teaching International, 55*(3), 366-375. https://doi.org/10.1080/14703297.2016.1231617

Lisciandro, J. G., Jones, A., & Geerlings, P. (2018). Enabling learners starts with knowing them: Student attitudes, aspiration and anxiety towards science and maths learning in an Australian pre-university enabling program. *Australian Journal of Adult Learning, 58*(1), 13-40.

Li, Y., Yang, N., Zhang, Y., Xu, W., & Cai, L. (2021). The relationship among trait mindfulness, attention, and working memory in junior school students under different stressful situations. *Frontiers in Psychology, 12*. https://www.frontiersin.org/article/10.3389/fpsyg.2021.558690

Lu, S., Huang, C.-C., & Rios, J. (2017). Mindfulness and academic performance: An example of migrant children in China. *Children and Youth Services Review, 82*, 53-59. http://dx.doi.org/10.1016/j.childyouth.2017.09.008

Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology Research and Behavior Management*, *11*(1), 311–322. https://doi.org/10.2147/PRBM.S141421

Mackenzie, E. R., Fegley, S., Stutesman, M., & Mills, J. (2020). Present-moment awareness and the prosocial classroom: Educators' lived experience of mindfulness. *Mindfulness*, *11*(12), 2755–2764. https://doi.org/10.1007/s12671-020-01483-7

MacKillop, J., & Anderson, E. J. (2007). Further psychometric validation of the Mindful Attention Awareness Scale (MAAS). *Journal of Psychopathology and Behavioral Assessment*, *29*(4), 289–293. https://doi.org/10.1007/s10862-007-9045-1

Mahmood, L., Hopthrow, T., & Moura, G. R. (2016). A moment of mindfulness: Computer-mediated mindfulness practice increases state mindfulness. *PloS One*, *11*(4).

Maloney, E. A., Sattizahn, J. R., & Beilock, S. L. (2014). Anxiety and cognition. *Interdisciplinary Reviews: Cognitive Science*, *5*(4). https://doi. 10.1002/wcs.1299

Maloney, E. A., Schaeffer, M. W., & Beilock, S. L. (2013). Mathematics anxiety and stereotype threat: Shared mechanisms, negative consequences and promising interventions. *Research in Mathematics Education*, *15*(2), 115-128.

Mapel, T. (2012). Mindfulness and education: Students' experience of learning mindfulness in a tertiary classroom. *New Zealand Journal of Educational Studies*, *47*(1), 19-32. https://doi.10.3316/informit.671242398810407

Markle, G. (2017). Factors influencing academic achievement in undergraduate social science research methods courses: A mixed methods analysis. *Teaching Sociology*, *45*(2), 105-115. doi:10.1177/0092055X16676302

Martin, W. E., & Bridgmon, K. D. (2012). *Quantitative and statistical research methods: From hypothesis to results*. Jossey-Bass.

Mattarella-Micke, A., Mateo, J., Kozak. M. N., Foster, L., & Beilock, S. L. (2011). Choke or thrive? The relation between salivary cortisol and math performance depends on individual differences in working memory and math-anxiety. *Emotion, 11*(4).

Maxwell, S. (2001). When to use MANOVA and significant MANOVAs and insignificant ANOVAs or vice versa. *Journal of Consumer Psychology, 10*(1).

Miller, C. J., Borsatto, J., & Al-Salom, P. (2019). Testing a quick mindfulness intervention in the university classroom. *Journal of Further and Higher Education*, *43*(6), 839–847. https://doi.org/10.1080/0309877X.2017.1409345

Millett, G., D'Amico, D., Amestoy, M. E., Gryspeerdt, C., & Fiocco, A. J. (2021). Do group-based mindfulness meditation programs enhance executive functioning? A systematic review and meta-analysis of the evidence. *Consciousness and Cognition, 95*. https://doi.org/10.1016/j.concog.2021.103195

Miralles-Armenteros, S., Chiva-Gómez, R., Rodríguez-Sánchez, A., & Barghouti, Z. (2019). Mindfulness and academic performance: The role of compassion and engagement. *Innovations in Education and Teaching International, 58*(1), 3-13. https://doi.org/10.1080/14703297.2019.1676284

Monshat, K., Khong, B., Hassed, C., Vella-Brodrick, D., Norrish, J., Burns, J., & Herrman, H. (2013). "A conscious control over life and my emotions" - Mindfulness practice and healthy young people. A qualitative study. *Journal of Adolescent Health, 52*(5). https://doi.10.1016/j.jadohealth.2012.09.008

Morr, C. E., Ritvo, P., Ahmad, F., Moineddin, R., & Team, M. V. C. (2020). Effectiveness of an 8-week web-based mindfulness virtual community intervention for university students on symptoms of stress, anxiety, and depression: Randomized controlled trial. *Journal of Medical Internet Research: Mental Health*, *7*(7), e18595. https://doi.org/10.2196/18595

Moustafa, A. A., Al-Emadi, A. A., & Megreya, A. M. (2021). The need to develop an individualized intervention for mathematics anxiety. *Frontiers in Psychology*, *12*. https://www.frontiersin.org/article/10.3389/fpsyg.2021.723289

Namkung, J. M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research*, *89*(3). https://doi.10.3102/0034654319843494

National Institute of Health. (2016). *Meditation: In depth.* U.S. Department of Health and Human Services. https://www.nccih.nih.gov/health/meditation-in-depth

Novak, E., & Tassell, J. L. (2017). Studying preservice teacher math anxiety and mathematics performance in geometry, word, and non-word problem solving. *Learning and Individual Differences, 54*. https://doi.10.1016/j.lindif.2017.01.005

O'Leary, K., Fitzpatrick, C. L., & Hallett, D. (2017). Math anxiety is related to some, but not all, experiences with math. *Frontiers in Psychology, 8.* https://doi.org/10.3389/fpsyg.2017.02067

Park, H., & Choi, H. (2021). The mediating effects of mindfulness and growth mindset on the relationship between occupational stress and happiness among clinical nurses. *Korean Journal of Occupational Health Nursing*, *30*(2), 68–77. https://doi.org/10.5807/KJOHN.2021.30.2.68

Pizzie, R. G., Raman, N., & Kraemer, D. J. M. (2020). Math anxiety and executive function: Neural influences of task switching on arithmetic processing. *Cognitive, Affective, and Behavioral Neuroscience, 20*(2). http://dx.doi.org/10.3758/sl3415-020-00770-z

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement*, *42*(2), 551–557. https://doi.org/10.1177/001316448204200218

Porter, T., Catalán Molina, D., Cimpian, A., Roberts, S., Fredericks, A., Blackwell, L. S., & Trzesniewski, K. (2022). Growth-mindset intervention delivered by teachers boosts achievement in early adolescence. *Psychological Science*, *33*(7), 1086–1096. https://doi.org/10.1177/09567976211061109

Quach, D., Jastrowski Mano, K. E., & Alexander, K. (2016). A randomized controlled trial examining the effect of mindfulness meditation on working memory capacity in adolescents. *Journal of Adolescent Health*, *58*(5), 489–496. https://doi.org/10.1016/j.jadohealth.2015.09.024

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

Rasch, D., & Guiard, V. (2004). The robustness of parametric statistical methods. *Psychology Science, 46*(2), 175-208.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554.

Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Taht, K. (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*(46). https://doi.org/10.1186/s40594-020-00246-z

Sampl, J., Maran, T., & Furtner, M. R. (2017). A randomized controlled pilot intervention study of mindfulness-based self-leadership training (MBSLT) on stress and performance. *Mindfulness, 8,* 1393-1407. https://doi.10.1007/s12671-017-0715-0

Samuel, T. S., Buttet, S., & Warner, J. (2022). "I can math, too!": Reducing math anxiety in STEM-related courses using a combined mindfulness and growth mindset approach (MAGMA) in the classroom. *Community College Journal of Research and Practice*. https://www.tandfonline.com/doi/abs/10.1080/10668926.2022.2050843

Samuel, T. S., & Warner, J. (2021). "I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. *Community College Journal of Research and Practice*, *45*(3), 205-222.

Saraff, S., Tiwari, A., & Rishipal. (2020). Effect of mindfulness on self-concept, self-esteem and growth mindset: Evidence from undergraduate students. *Journal of Psychosocial Research*, *15*(1), 329–340. https://doi.org/10.32381/JPR.2020.15.01.28

Schonert-Reichl, K. A., Oberle, E., Lawlor, M. S., Abbott, D., Oberland, T. F., Diamond, A., & Thomson, K. (2015). Enhancing cognitive and social-emotional development through a simple-to-administer mindfulness-based school program for elementary school children: A randomized controlled trial. *Developmental Psychology, 51*(1), 52-66. http://dx.doi.org/10.1037/a0038454

Shi, Z., & Liu, P. (2016). Worrying thoughts limit working memory capacity in math anxiety. *PloS One*, *11*(10), e0165644–e0165644. https://doi.org/10.1371/journal.pone.0165644

Skagerland, K., Ostergren, R., Vastfjall, D., & Traff, U. (2019). How does mathematics anxiety impair mathematical abilities? Investigating the link between math anxiety, working memory, and number processing. *PLoS One, 14*(1), 1-17.

Smith, A. B., Street, M. A., & Olivarez, A. (2002). Early, regular, and late registration and community college student success: A case study. *Community College Journal of Research and Practice, 26*, 261-273.

Stoehr, K. J. (2017). Mathematics anxiety: One size does not fit all. *Journal of Teacher Education, 68*(1), 69-84. doi:10.1177/0022487116676316

Sullivan, L. M. (2008). Repeated measures. *Circulation, 117*(9). https://doi.org/10.1161/CIRCULATIONAHA.107.654350

Supekar, K., Iuculano, T., Chen, L., & Menon, V. (2015). Remediation of childhood math anxiety and associated neural circuits through cognitive tutoring. *Journal of Neuroscience, 35,* 12574–12583. doi:10.1523/jneurosci.0786-15.2015

Szczygiel, M. (2021). The relationship between math anxiety and math achievement in young children is mediated through working memory, not by number sense, and it is not direct. *Contemporary Educational Psychology, 65*. https://doi.10.1016/j.cedpsych.2021.101949

Tassell, J., Gerstenschlager, N. E., Syzmanski, T., & Denning, S. (2020). A study of factors impacting elementary mathematics preservice teachers: Improving mindfulness, anxiety, self-efficacy, and mindset. *School Science and Mathematics, 120*(6).

Trammel, R. C. (2017). Tracing the roots of mindfulness: Transcendence in Buddhism and Christianity. *Journal of Religion & Spirituality in Social Work: Social Thought, 36*(3), 367–383.

Tufford, L., Katz, E., & Etherington, C. (2019). BSW student perspectives on the utility of brief, classroom-based mindfulness practices. *Smith College Studies in Social Work, 89*(3).

Vestad, L., & Tharaldsen, K. B. (2021). Building social and emotional competencies for coping with academic stress among students in lower secondary school. *Scandinavian Journal of Educational Research*, 1–15. https://doi.org/10.1080/00313831.2021.1939145

Vorontsova-Wenger, O., Ghisletta, P., Ababkov, V., Bondolfi, G., & Barisnikov, K. (2021). Short-mindfulness-based intervention for psychological and academic outcomes among university students. *Anxiety, Stress, and Coping*, 1-17.

Warner, R. M. (2021). *Applied statistics I: Basic bivariate techniques* (3rd ed.). Sage.

Weed, K., Ursy, C. H., & Stafford, J. (2021). College students who are mindful about math achieve better grades. *Mind, Brain, and Education*, 1-6. https://doi.10.1111/mbe.12308

Weger, U. W., Hooper, N., Meier, B. P., & Hopthrow, T. (2012). Mindful maths: Reducing the impact of stereotype threat through a mindfulness exercise. *Consciousness and Cognition, 21*, 471-475. doi:10.1016/j.concog.2011.10.011

Westfall, R. S., McAuley, A. J., & Millar, M. (2021). The influence of implicit math anxiety on math achievement. *Psychological Reports, 124*(6), 2651-2668. https://doi.10.1177/0033294120964055

Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. *International Management Review, 15*(1).

Wilson, S. (2013). Investigating rural pre-service teachers' mathematics anxiety using the Revised Mathematics Anxiety Scale (RMARS). *Australian and International Journal of Rural Education, 23*(3), 1-11.

Yeager, D. S., & Dweck, C. S. (2020). What can be learned from growth mindset controversies? *American Psychologist, 75*(9), 1269–1284. https://doi.org/10.1037/amp0000794

Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., Tipton, E., Schneider, B., Hulleman, C. S., Hinojosa, C. P., Paunesku, D., Romero, C., Flint, K., Roberts, A., Trott, J., Iachan, R., Buontempo, J., Yang, S. M., Carvalho, C. M., … Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature, 573*. https://doi.org/10.1038/s41586-019-1466-y

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

Appendix

Students in the intervention group retroactively reported their level of engagement with the intervention throughout the semester on a scale of 1 to 100, with higher scores indicative of higher levels of engagement. The descriptive statistics revealed a negatively skewed, bimodal distribution for self-reported engagement, which prompted further exploration as to how a student's level of engagement could influence the intervention's impact. A total of 34 students from the intervention group reported their level of engagement (M=63.73, Median=75, Minor mode=20, Major mode=80). Students were divided into two groups reflecting low engagement (scores of 0-30) and high engagement (scores of 70-100). The two groups were not significantly different in demographic factors for age, race, or gender (p>.05). The average level of engagement in the low engagement group was 16.75, whereas the average for the high engagement group was 82.64.

A series of independent sample *t*-tests were conducted on the scores for the Revised Math Anxiety Rating Scale. At each time of assessment, there were not significant differences between the two groups in level of math anxiety, which is summarized in Table 7. However, paired samples *t*-tests revealed that the high engagement group significantly decreased in their math anxiety from Time 1 to Time 3 with a large effect size, $t(21)=5.525$, $p<.001$, Cohen's $d=1.18$, while the low engagement group did not have any significant change, $t(7)=-.196$, $p=.425$, Cohen's $d=.07$. This corresponded to the high engagement group reducing by 16% while the low engagement group increased by 6%, which is a significant difference in percent change between the two groups, $t(28)=2.808$, $p=.004$, Cohen's $d=1.16$.

Table 7.

Results of Independent Sample t-test Depending on Engagement

Outcome	High Engagement		Low Engagement		*t*	df	*p*	Cohen's *d*
	M	*SD*	*M*	*SD*				
Math Anxiety								
Time 1	77.73	17.00	67.50	19.59	-1.40	28	.086	.58
Time 2	67.84	17.71	68.29	13.60	.06	27	.476	.03
Time 3	64.73	17.46	68.60	14.14	.56	28	.289	.23
Mindfulness								
Time 1	50.73	11.63	43.87	12.26	-1.41	28	.085	.58
Time 2	49.95	11.33	45.71	12.16	-.85	27	.202	.37
Time 3	50.27	9.92	46.87	13.91	-.74	28	.231	.31
Math Outcomes								
HW 1	84.50	23.21	95.97	4.93	1.37	27	.091	.57
HW 2	88.83	19.82	93.88	7.10	.70	27	.246	.29
HW 3	87.01	19.09	92.92	9.18	.83	27	.206	.35
Quiz 1	84.56	10.24	88.85	4.20	1.14	27	.132	.47
Quiz 2	89.68	9.94	94.17	4.27	1.22	27	.116	.51
Quiz 3	82.34	16.12	82.72	8.51	.06	27	.475	.03
Exam 1	79.19	12.09	80.33	7.00	.25	27	.403	.10
Exam 2	79.81	10.83	81.89	10.75	.46	27	.324	.19
Exam 3	77.70	11.85	79.90	8.90	.47	27	.320	.20
Final Grade	83.73	9.71	87.85	3.82	1.15	27	.130	.48
Percent Change								
RMARS 1→3	-15.96	15.13	6.12	27.65	2.81	28	.004	1.16
MAAS 1→3	1.77	18.98	7.39	21.83	.69	28	.248	.29
HW 1-HW 3	4.23	18.13	-3.15	8.90	-1.09	26	.142	.46
Quiz 1-Quiz 3	-2.00	18.77	-6.97	7.60	-.72	27	.239	.30
Exam 1-Exam 3	-0.43	16.30	-0.39	9.36	.006	27	.498	.002

Independent sample *t*-tests revealed there were not any significant differences in level of mindfulness between the two groups at any time of assessment (See Table 7). Moreover, the high engagement group did not have any significant change in mindfulness from Time 1 to Time 3 ($t(21)=.235$, $p=.408$, Cohen's $d=.05$) and neither did the low engagement group ($t(7)=-.909$, $p=.197$, Cohen's $d=.32$). There were also no significant differences between the two groups in terms of homework, quiz, or exam performance, or final grade ($p>.05$, see Table 7).

Paired samples *t*-tests suggests that the high engagement group did not significantly change in their homework scores ($t(20)=-.874$, $p=.196$), quiz scores ($t(20)=.655$, $p=.260$), or exam scores ($t(20)=.553$, $p=.293$). Similarly, the low engagement group did not have any significant changes in their homework scores ($t(7)=.1071$, $p=.160$) or exam scores ($t(7)=.168$, $p=.436$); however, they significantly decreased in their quiz grades from Time 1 ($M=88.85$, $SD=4.20$) to Time 3 ($M=82.72$, $SD=8.51$; $t(7)=2.64$, $p=.017$, Cohen's $d=.934$).

Interpretation

Exploring changes in students who were engaged with the intervention compared with more disengaged students is critical to disentangle the impact of the intervention. At the beginning of the semester, the students who reported high engagement had higher math anxiety, with a moderate effect size, although this was not a significant difference. This suggests that the students who most need an intervention to reduce their anxiety towards math may self-select to participate in such an intervention.

Additionally, in accordance with the correlation between self-reported engagement and percent change in math anxiety, students that were highly engaged had a significant decrease in math anxiety whereas students that were disengaged slightly increased from Time 1 to Time 3. This highlights how the intervention's impact is dependent on the participation of the individual students. While interventions in the classroom occur at the group level (i.e., Samuel & Warner, 2021), this research further highlights how an individual's level of engagement will determine the benefit, with greater engagement leading to greater impact on math anxiety. This finding also draws attention to how the effect of the intervention which is analyzed by comparing the intervention and control groups is diluted due to students who do not engage with the intervention.

At the beginning of the semester, the high engagement group had insignificantly higher mindfulness than the low engagement group with a moderate effect size. This suggests that students who are more mindful are willing to engage with the intervention, however, the lack of significance limits any definitive claims. There were no significant changes in mindfulness throughout the semester for students with high or low engagement. While a small sample limits the statistical power, it is possible that the MAAS, which assesses the more stable trait mindfulness is not sensitive enough to detect changes that occur in state mindfulness as previous research has suggested brief mindfulness meditation can benefit state mindfulness (Mahmood et al., 2016).

These analyses also supported a pattern that was observed in comparing the intervention group and control group. The control group significantly reduced in their quiz performance. In contrast, the intervention group maintained their performance on quizzes from Time 1 to Time 3. Similarly, the poorly engaged students had a drop in quiz performance that was not observed in the students with high engagement. This research further supports the benefit of the intervention for performance on moderate stress assignments. These analyses bolster how it is critical to determine individual-level engagement with a group-level intervention. Moreover, it provides support that the students who are willing to engage with a classroom-based mindfulness and growth mindset intervention will reap psychological and academic benefits.