5-7-2021

The Effects of Mindfulness Interventions on Undergraduate Students' Math Anxiety

Elysia Garza
elysiagm@gmail.com

UNIVERSITY OF NORTHERN COLORADO

Greeley, Colorado

The Graduate School

THE EFFECTS OF MINDFULNESS INTERVENTIONS ON UNDERGRADUATE STUDENTS' MATH ANXIETY

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science

Elysia Garza

College of Educational and Behavioral Science
School of Psychological Sciences
Educational Psychology

May 2021

This Thesis by: Elysia Garza

Entitled: *The Effects of Mindfulness Interventions on Undergraduate Students' Math Anxiety*

has been approved as meeting the requirement for the Degree of Master of Arts in the College of Education and Behavioral Science in School of Psychological Sciences, Program of Educational Psychology.

Accepted by the Thesis Committee:

_____

Molly M. Jameson, Ph.D., Chair

_____

Kevin Pugh, Ph.D., Committee Member

_____

Michael Kimball, Ph.D., Committee Member

Accepted by the Graduate School

_____

Jeri-Anne Lyons, Ph.D.
Dean of the Graduate School
Associate Vice President for Research

ABSTRACT

Garza, Elysia. *The Effects of Mindfulness Interventions on Undergraduate Students' Math Anxiety*. Unpublished Master of Arts thesis, University of Northern Colorado, 2021

This study attempted to examine the relationship between math anxiety and mindfulness using an experimental design. The aim of this study was to learn if a brief daily mindfulness practice (yoga or meditation) could increase participants' levels of perceived mindfulness and decrease their reported math anxiety. Participants (n=24) were assigned to an intervention group (i.e., meditation, yoga, control) and their mindfulness and math anxiety were measured pre, during-, and post-interventions. While small sample size and large attrition leave inferential statistics impossible to analyze, this research did show an increase in mindfulness and decrease in math anxiety throughout the study for all participants.

ACKNOWLEDGMENTS

This thesis would not have been possible without the love and support of my family and friends who have helped navigate these years of graduate school. Thank you for helping me to juggle school, work, and children. Thank you Mom, for helping with my daughters and around the house. Mary Lucas, thank you for being an expert in the research study and for helping at a moment's notice. Thank you to my husband who has always believed in me. You have been my rock, and I could not have done this without you.

To my committee, thank you for all of your brilliant suggestions and support. Dr. Kevin Pugh, thank you for being a wonderful educator whom I aspire to emulate in some fashion; your thorough feedback and insight throughout this process was imperative. Thank you Dr. Michael Kimball, for serving on this committee and lending your expertise in meditation interventions and scholarship. Your guidance in this subject was pivotal to this work. Finally, to my committee chair Dr. Molly Jameson, this project could not have been completed without your guidance and support throughout. The whole world has gone upside down, but you remained a steady lifeline. I cannot express eloquently enough how much your support has meant to me throughout this time as a graduate student, but you have taught me about perseverance and trust. Thank you for being the educator and person you are.

Lastly, I express my deepest gratitude to UNC and all the faculty and administrators who work diligently to give all students an education. I have been so blessed to graduate from this educational institution.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Mindfulness is defined as the ability to focus attention purposefully on the current moment. Recently psychologists have demonstrated the power of mindfulness practices to aid in several kinds of psychological therapies, such as Mindfulness-Based Stress Reductions (MBSR) created by Jon Kabat-Zinn (Quaglia et al., 2015) and Dialectical Behavioral Therapy (DBT) (Bishop, 2002; Bishop, et al., 2004; Richmond, et al., 2017). The benefits of mindful practice include increased attention, executive function, self-regulation, prosocial behavior, and feelings of well-being (Viglas & Perlman, 2018). The effects of mindfulness have been demonstrated in numerous studies and it has become a reputable therapy tool, especially in clinical and social work settings and in cases of anxiety or depression (Vohra-Gupta, et al., 2007). When mindfulness is utilized through movement, specifically yoga practice, the benefits are extended to physical improvements in neuromuscular, cardiopulmonary, and musculoskeletal health (Galatino, et al., 2008).

The ability to be attentive and aware in the moment is what helps focus attention on the task at hand and not engage in ancillary or distracting behaviors. With higher mindfulness and awareness comes more conscious decision making rather than thoughtless reactivity. This is especially important for university students who may suffer from anxiety of many kinds (Hunt, et al., 2018). By establishing a mindfulness routine, students may cultivate skills that help to alleviate anxiety, which interferes with learning new information and producing learned

information for later use (Moran, 2016). Students can experience anxiety over academic content areas, and one area that is regularly reported and studied in college students is math anxiety. Math anxiety can lead to students choosing degree paths that require fewer high level math courses (Ma, 1999). This limits math-anxious students' future career choices (Hendy, et al., 2014; Lefevre, et al., 1992). This is particularly evident in marginalized groups in which a negative stereotype about their group exists (Spencer, et al., 1999). Mindfulness practices can help students learn to bypass these negative thoughts and feelings that feed their anxiety. Mindfulness can help students recognize when anxiety is triggered and respond in more adaptive and healthy ways, such as positive self-talk through affirmations, focus on breathing, and acknowledgement of the negative thoughts from the perspective of an observer so as not to be affected or bothered by them. It seems logical that the introduction of mindfulness interventions to undergraduate students could lead to many benefits. Recently, ecological momentary assessment (EMA) has been used to measure mindfulness as this method allows in-the-moment measures of the construct (Ruscio, et al., 2016). Research that examines the effect of mindfulness interventions on math anxiety using EMA has not been conducted, to the author's knowledge. This proposed research seeks to examine how mindfulness interventions impact university students' math anxiety using a smartphone app that allows for measures of mindfulness and math anxiety while the participant is in the moment.

Purpose

The current study seeks to examine the impact of mindfulness interventions on undergraduate students' math anxiety and mindfulness levels through Ecological Momentary Assessment. Participants will be randomly assigned to one of three conditions. Two mindfulness interventions (e.g. yoga or meditation) and a control group. The yoga intervention is a kind of

mindful movement. The meditation mindfulness condition will be modeled on the Koru method in which attention to the breath and sensations is encouraged. The control group will be asked to practice study skills instead of taught a mindfulness activity. All participants will complete pre- and post-test measures of anxiety and mindfulness. Participants will receive activities every other day via a smartphone application and will complete anxiety and mindfulness items after each activity. The hypothesis for the current study is:

H1 Participants who receive a mindfulness intervention will have an increase in mindfulness and a decrease in math anxiety scores from pre- to post-test. This change will be significantly different than the study skills control group.

CHAPTER II

REVIEW OF THE LITERATURE

This literature review explores the relationships between learning and math anxiety, and the potential benefits of mindfulness practices. Certain emotions toward academics are not conducive to learning. Anxiety is one such emotion that can interfere with student learning and performance. Anxiety is defined as feelings of apprehension and somatic stress responses (e.g., tension) in which an individual dreads the approach of a future event (American Psychological Association, 2018). When this anxiety is directed toward academic events (e.g., exam, presentation, or assignment), the student experiences academic anxiety. Teenage students with high levels of academic anxiety have a greater likelihood of dropping out of high school or failing to graduate high school (Moran, 2016). Individuals who are highly anxious may experience various maladaptive symptoms such as worry and rumination which may lead to self-destructive behaviors such as procrastination or the inability to begin or finish a project (Pizzie & Kraemer, 2019). Some students thrive in a rigorous academic environment while others crumble under the stress. High anxiety can make it difficult for students to complete coursework and can also hinder the student's ability to learn the content in the first place, resulting in lower performance (Ashcraft & Krause, 2007; Moran, 2016; Tobias, 1979). A history of poor academic performance can serve to fuel anxiety and lead to future inadequate performance and more maladaptive coping mechanisms such as fear of failure, performance anxiety, and any number of

related anxiety disorders (Hjeltnes et al., 2015). This cycle leads students to dislike school and avoid some types of academic advancement like the pursuit of higher education.

Mindfulness practices can increase the amount of content that students learn because it increases their attention, which is a necessary first step in the learning process (de Jong, 2010). When students are fully present and not distracted by outside thoughts and worries, they have a greater chance of learning the material presented. Mindfulness training has the potential for many positive outcomes for students in particular because it can teach them how to purposefully wield their attention which can allow them to more effectively use their learning time.

Mindfulness based interventions (MBIs) and therapies have been very successful with adults who deal with anxieties (Hjeltnes et al., 2015). MBIs may also be helpful in education and give students important tools that can help them gain a better grasp of educational content. The subject of mathematics has long been considered one of the least popular school subjects for students; though the reasons for this are varied, one contributor is math anxiety (Clark et al., 2017). If mindfulness practices can serve to decrease the effects of math anxiety in students, it is possible that math could be framed in a more positive light in the minds of students.

The Learning Process and Anxiety

Learning is a complex task, and it is more complex than students often think. While some learning is explicit and intentional, much learning is implicit and impacted by internal factors such as interest and emotions (Crede & Kuncel, 2008). During the learning process, we must encode knowledge, i.e. put it into our memory system. In order to do this, we must pay attention. But attention alone is not a sufficient prerequisite for learning; we also need to have adequate resources to process and encode the information we pay attention to. If we are attending to the information and have adequate resources, the information will likely be successfully encoded. If

we are not attending, or our resources are limited, we are less likely to successfully encode information. One thing that can reduce the available resources we have to aid our encoding of information is anxiety. Low levels of anxiety are healthy, as a manageable level of anxiety helps us stay safe and prepares the body to act and address the anxiety-inducing trigger in a productive manner (Nairne, 2006). However, when anxiety is too high, it interferes with our functioning. High levels of anxiety can manifest as rumination, in which unhelpful or negative self-relevant thoughts are mentally repeated and interfere with our ability to effectively learn (Barcaccia et al., 2019; Moran, 2016).

In order for information to be encoded into long term memory, which is when it is learned, we need to process the information in a meaningful way in our working memory, the portion of memory that a person is currently using and paying attention to (Moran, 2016). Working memory is limited in resources, as it cannot hold very much information (Moran, 2016; Mrazek et al., 2013). Some resources are used by the task itself, called intrinsic load (de Jong, 2010), but the available resources are now reduced. Strategies needed to complete the task or relevant known information recalled from long-term memory use some of those resources, called germane load (de Jong). Anything else that takes resources in the working memory that is not related to the task is called extrinsic load (de Jong), and extrinsic load can keep us from effectively recalling strategies or giving resources to the task. For example, to solve the problem "3x-7=20" you must hold the information about the problem and what it is asking you to do in your working memory; you must also recall the strategy of isolating x on one side of the equation by adding 7 to each side and then dividing each side by 3. Individuals who have anxiety about their ability to complete this math problem are likely going to engage in negative self-talk (e.g. "I am too stupid to figure this out") or self-defeating statements (e.g., "I don't know why I

even try"), and this is a source of extrinsic load that reduces valuable working memory resources (Tobias, 1979). Working memory resources are impacted by these highly anxious worries and thoughts and makes it increasingly difficult for students to perform well on assessments because they experience high cognitive load (Sweller, 1994). Highly anxious students consistently perform at a deficit when compared to their low anxiety peers (Pizzie & Kraemer, 2019; Tobias, 1979). High levels of anxiety can send students into a negative and unproductive cycle of fear and failure (Hjeltnes et al., 2015).

This relationship between anxiety and working memory capacity has been supported by numerous researchers. For example, test-anxious individuals experience a working memory system "clogged" with anxious thoughts when faced with a test, which adds extrinsic load and reduces the resources available for germane load, or the recall of learned information from long-term memory (de Jong, 2010; Pizzie & Kraemer, 2019; Sweller, 1994). Similarly, Owens and colleagues (2012), found that students with low working memory capacity (and thus reduced resources) were the most impacted by high levels of anxiety; students with high working memory capacity (and thus increased resources) were less impacted by their high anxiety. In addition to the relationship existing between test and general anxiety, reduced working memory resources, and impacted learning, researchers have consistently found this relationship in math anxiety as well.

Math Anxiety and Learning

Highly math anxious students feel dread when anticipating performing or actually performing arithmetic (Ashcraft, 2002; Brunyé et al., 2013), and this can be experienced as physical pain for some extremely math anxious students (Lyons & Beilock, 2012). Math anxiety is typically related to decreased math self-confidence (i.e., self-efficacy) (Hendy et al., 2014), an

avoidance of math (Ma, 1999), and lower math performance (Ashcraft & Krause, 2007). This cycle of anxiety, low confidence, avoidance, and decreased performance perpetuates a self-fulfilling prophecy in which the student's low grades confirm their need for low confidence, high anxiety, and continued avoidance (Karimi & Venkateson, 2009). We then find many students enroll in arithmetic courses only because it is expected and required by a school (Gogol et al., 2016), not because of perceived value or interest in mathematics.

Math anxiety impacts working memory capacity similarly to other forms of anxiety. Ashcraft and Kirk (2001), Ashcraft and Krause (2007), and Maloney and Beilock (2012) among many others explained the decreased working memory capacity in highly math anxious individuals: the worry associated with math performance for these individuals compromises working memory resources. Surprisingly, Ramirez and colleagues (2013) found that the math performance of highly math anxious students with high working memory capacity was impacted more severely than those with low working memory capacity; the authors attributed this to the high-capacity students' use of strategies that use a lot of working memory resources which leaves fewer resources that are compromised by the math anxiety. The worry and rumination associated with high math anxiety can harm self-concept and hinder one's ability to successfully learn and apply math concepts (Jameson & Fusco, 2014).

Students of all ages are found to experience math anxiety, though it does increase as students get older (Maloney & Beilock, 2012) and is more often self-reported by female students (Ashcraft, 2002; Ganley & Vasilyeva, 2014). Though it is unclear exactly why some students develop math anxiety, there are both personal and social components. The brains of math anxious children process information differently than those of non-math anxious children (Young, et al., 2012), and it is possible that these brain differences result in less mathematical

ability or a propensity for developing math anxiety. From a social perspective, certain teacher behaviors (e.g., modeling math anxious behaviors, Beilock et al., 2019; being perceived as unapproachable and teacher-centered, Jameson, 2020) have been found to influence students' math anxiety levels.

Decreasing Academic Anxiety

By teaching students how to decrease their anxiety, they can increase their performance. A number of strategies have been studied and found effective in various ways. Some strategies focus on teaching cognitive and learning skills. Crede and Kuncel (2008) stated that focusing on improving faulty study skills in anxious students will improve their performance. Other researchers support giving anxious students opportunity to practice the skills (e.g., math computation) so that their knowledge increases (Jansen et al., 2013). Other strategies take more of a cognitive behavioral approach by teaching learners to think about their anxiety in a different way. When learners reframe their anxiety as excitement (different emotion with similar physiological reaction), they have higher performance than those who do not reframe anxiety as excitement (Brooks, 2014). This is likely because reframing anxiety as a positive emotion can help an individual avoid the negative outcomes of high anxiety. Cognitive behavioral techniques (e.g., reframing automatic negative thoughts) are highly effective with anxiety disorders of all types, and some research shows that these techniques are superior to other treatments for anxiety (Silk et al., 2018). One component of cognitive behavioral techniques is teaching mindfulness, or focus and awareness on the present moment.

Mindfulness: What it is and How it Helps Anxiety

Mindfulness is purposeful attention to the present moment and awareness of the thoughts and sensations one is experiencing (Kabat-Zinn, 2015). The opposite of being mindful is to be

mindless; distracted by possible future events, ruminating over past events, or daydreaming about unrelated subjects. Mindfulness is rooted in Eastern traditions of Buddhism and the practices of meditation and yoga (Kabat-Zinn, 2015; Nilsson & Kazemi, 2016). When an individual is practicing mindfulness, they are more aware of thoughts, feelings and sensations being experienced (Flook et al., 2010), more able to self-regulate behaviors (Viglas & Perlman, 2018), more attentive to the present experience (Basso et al., 2019), are more resilient (Ramasbramanian, 2017), less judgmental (Barcaccia et al., 2019), and have a greater sense of well-being (Sirois & Tosti, 2012). This ancient construct has managed to stand the test of time as modern research on mindfulness interventions indicate that it can lead to the aforementioned benefits of the mindful state. Due to the increasing interest in mindfulness research, researchers have found it necessary to operationally define this seemingly simple construct.

The mindfulness construct does not yet have a universally agreed upon operational definition, but Bishop (2004) and colleagues have proposed a model of mindfulness. These mindfulness researchers suggested that the construct of mindfulness is comprised of two components: the first is based on one's ability to self-regulate attention (Bishop et al.). This refers to the ability of one to be aware of the present moment and where attention is currently being focused (Bishop et al.). The second component is orientation to experience which refers to the attitude one maintains in the moment because this colors how the observer perceives the moment (Bishop et al., 2004).

Mindfulness interventions refer to many things that involve increasing focus on the present moment, also known as contemplative practices (e.g., meditation, breath work, yoga, and tai chi) (Shapiro et al., 2015). Yoga and meditation are two common types of mindfulness practice that have been effective in research and are of interest in the current study. Yoga is a

type of mindfulness practice that incorporates physical poses called asanas and slow deliberate breathing called pranayama to bring the practitioner into the present moment (Galatino et al., 2008). Originally yoga was intended to join the mind and body of the individual through the purposeful postures, breathing, and meditation, which allow the practitioner to develop balance, strength, and focus (Hagen & Nayar, 2014). Yoga has been practiced in various forms and incarnations for centuries and the health benefits that early practitioners professed are being verified by researchers today (Galatino et al., 2008; Richmond et al., 2017). Studies of yoga interventions have found evidence which supports the claims that yoga practice improves physical and mental health as well as prosocial behavior and a sense of well-being (Desai et al., 2015; Galatino et al., 2008).

Meditation is a group of relaxation and emotion- and attention-regulatory practices that seek to focus attention on the moment (Lutz et al., 2008). This often involves focusing of attention on a chosen object and continually monitoring awareness and returning it to the chosen object if attention wanders (Lutz et al., 2008). This sometimes involves breathing techniques. Meditation interventions have been found to reduce student stress (Hunt et al., 2018), increase mood and attention and decrease anxiety (Basso et al., 2019; Beauchemin et al., 2008), and reduce math avoidance behaviors (Carlin & Ahrens, 2012).

Mindfulness interventions have been shown effective in increasing students' social skills and academic performance (Beauchemin et al., 2008), as well as their math-specific performance and attitudes. Bellinger and associates (2015) investigated the connection between mindfulness interventions, anxiety, and performance on high-stakes math exams and found that participants who listened to mindfulness breathing exercises performed better on difficult novel math tasks than those who did not listen to the exercise. Similarly, Brunyé and colleagues (2013) found that

students trained in mindful breathing exercises showed the largest decreases in math anxiety and the highest increases in math performance.

Mindfulness training seems to benefit students with anxiety, and research suggests that its efficacy can be explained by ideas of the limited resources in working memory. Because mindfulness is a focus on the present moment and noticing other thoughts but not focusing on them, an automatic negative thought related to math anxiety would be noted, but not dwelled upon, by the mindful practitioner. Researchers suggest that that mindfulness may increase working memory capacity especially with complex cognitive tasks requiring more working memory to complete (Mrazek et al., 2013). It is also possible that increased mindfulness teaches the practitioner to separate themselves from the experience of overwhelming emotions (Carlin & Ahrens, 2012), which has been shown in depressed individuals who, once trained in mindfulness, can recognize negative feelings and be present to debate the negative feelings (Hoare et al., 2011). It is possible that the same is true for anxious individuals.

Using Ecological Momentary Assessment to Measure Mindfulness and Anxiety

Many studies on mindfulness and anxiety use retroactive self-report (Bostanov et al., 2018), which can be less valid as it relies upon participants' memories. However, Ecological Momentary Assessment (EMA) is a statistically powerful way to collect data in the moment (Zirkel et al., 2015). Data collected through EMA is more authentic as it is collected from participants' responses to data requests at various points throughout the day instead of reporting to a lab setting to complete measures. This powerful data collection method allows researchers to gather data from participants wherever their location, send reminders to participate in the study, and collect multiple points of data in real-time.

Though mindfulness research has been conducted extensively over the last few decades, it is not often that mindfulness is used as a measured outcome (Weis et al., 2020). In the current study we seek to address this discrepancy by using mindfulness scales. Because mindfulness is awareness of the moment, collecting data via EMA is sound methodology. Instead of asking retrospective questions about participants' general mindfulness, EMA allows the researcher to gather data about mindfulness in the moment. While EMA has been used with mindfulness (Ruscio et al., 2016), it has not been studied extensively in the realm of education (Bostock et al., 2019) nor at all with math anxiety and meditation.

A review of the literature revealed that math anxiety is detrimental for academic pursuit and success. We noted that mindfulness practices can be beneficial for those who are anxious. We found gaps in previous research on the relationship between mindfulness and math anxiety. Few studies examining math anxiety and mindfulness exist and none have attempted to measure mindfulness. The implementation of EMA methods are also valuable in measuring these constructs in the moment as students are experiencing them. This study is necessary because it attempts to explain the relationship between math anxiety and mindfulness in order to extend the research field and help those in charge of educational programs to make good decisions for teachers and students.

CHAPTER III

METHODOLOGY

The current study was designed to examine the relationship between mindfulness interventions and their effects on participants' rated levels of mindfulness and math anxiety.

Participants

A total of 33 participants completed this study, though only 24 participants' data were complete and used in data analysis. All participants were undergraduate students at a mid-sized public university in the mountain region of the United States. Participants were recruited through a psychology participant pool in which students participate in research for earning course credit (with alternative assignments to avoid coercion). Of the 33 participants recruited in Spring of 2020, 24 identified as female and nine identified as male. All participants ranged in age from 18 to 24 years of age at the time of data collection, and the racial/ethnic identity of the participants was predominantly White (75%) with the remaining participants identifying as Latin or Hispanic (12%), Black (9%), and Native Hawaiian or Pacific Islander (3%). All participants provided informed consent prior to participation in this study.

Measures and Materials

Mindfulness

Two measures of state mindfulness were selected for use in this study; two measures were used so that a longer measure could be used as a pre- and post-test measure, while a short measure could be used as a measure of ecological momentary assessment.

The *State Mindfulness Scale* (SMS; Tanay, & Bernstein, 2013) is a 21-item self-report measure developed to gauge the current mindfulness level of an individual. This mindfulness measure focuses on two domains to determine state mindfulness: present awareness (item example: “I was aware of different emotions that arose in me”) and attention of mind and body for a specified period of time (e.g., the last fifteen minutes; item example: “I clearly physically felt what was going on in my body”). Participants respond to each item on a 5-point Likert-type scale (1= not at all, 5= very well; range = 21-105). None of these questions were reverse coded. The SMS had strong internal reliability ($\alpha = .91$) in this study. Higher scores indicate a higher degree of mindfulness in the present state of the individual.

The *State Mindfulness Inventory* (SMI; Friese & Hofmann, 2016) is a brief five-item scale that measures state mindfulness in five areas: 1) nonreactivity to inner experiences (e.g., emotions, and thoughts; item: “right now, when I have distressing thoughts or images, I just notice them and let them go”), 2) observing the inner experience (item: “right now, I pay attention to my physical experiences”), 3) acting with awareness (item: “right now, I find myself doing things without paying attention”), 4) describing feelings with words (item: “right now, I am good at finding words to describe my feelings”), and 5) nonjudging of inner experiences (item: “right now, I tell myself that I shouldn’t be thinking the way I am thinking”). Participants respond with agree or disagree. Questions 3 and 5 were reverse coded. Higher scores indicate higher levels of state mindfulness. Previous studies report that the SMI has good internal consistency reliability. The SMI showed bad internal consistency reliability in the current study α ranged from -.43 to .76 across all six collection points. Therefore the results of the SMI seem unreliable.

Math Anxiety

The *Single-Item Math Anxiety scale* (SIMA*;* Nunez-Pena et al., 2014) is a single item on a 10-point scale (1 = not anxious, 10 = very anxious) that asks the student how anxious they feel in math. The reliability of this single item question has been validated through multiple studies and it has shown to measure math anxiety as well as longer scales (Nunez-Pena et al.)

Math performance. Randomly selected items with variation of difficulty level from the math computation subtest of the *Wide-Range Achievement Test 4th edition* (WRAT; Wilkinson, & Robertson, 2006) were used as short timed math tasks. These short math tests were used to arouse participants' math anxiety in the moment and were not used for the original intended purpose of the WRAT. As such, raw scores (as opposed to WRAT-provided standard scores) were used in data analysis.

Training Videos

Three training videos were created for use in this study. Each video was created by a content-area expert and filmed by the researcher. Each video was approximately 15-minutes in length and included introduction to content and practice of the material. The first video introduced meditation (based on Koru Mindfulness techniques) and was led by a certified meditation instructor. The second video introduced a chair-based yoga routine led by a certified yoga instructor. The third video introduced effective learning strategies and was led by a doctoral-level expert in educational psychology. All videos were uploaded to a private YouTube channel.

Procedure

After approval from the university Institutional Review Board in spring 2020, the study description was placed online to allow sign-ups for students in the participant pool. Based on the day and time that participants signed up, they were placed in one of three groups: *meditation group*, *yoga group*, or *learning (control) group.* Participants arrived at a designated classroom at their day/time with a group of approximately 3-5 participants in the same group. This 15 minute initial meeting was held with the researcher and the expert who contributed to the intervention videos. At this initial meeting, participants were given a brief (approximately 5-minute) introduction to the content (i.e., meditation, yoga, effective learning) by the expert. This allowed participants to receive initial face-to-face training, ask questions of the expert, and understand potential benefits and risks to their participation in the study (e.g., some research has shown that mindfulness practice can trigger traumatic memories and cause distress in the practitioner; Urbanowski & Miller, 1996). At this initial session, participants also provided an email address which they regularly accessed, and completed informed consent, demographic information, a 40-item timed (5-minute) math test, the SMS, and the SIMA. The data collection process and participant expectations of the study (see below) were then explained to the participants, participants were encouraged to practice the skill they learned about during the initial meeting every day, and they were given the opportunity to ask questions. Participants were then thanked and released. The initial meeting took approximately 15 minutes.

Each participant received an email from the researcher on Tuesday and Thursday each week for three consecutive weeks. The email contained a link to the training video on a private YouTube channel for that participant's group (i.e., meditation, yoga, effective learning) and a link to a Qualtrics survey which included the 5-item SMI and the 1-item SIMA as well as a 8-

item timed (one minute) WRAT math test. Every Friday for three consecutive weeks, the researcher emailed a 5- item compliance check questionnaire to participants via a Qualtrics survey that asked participants to indicate how often they had participated in their given intervention task in the last week as well as how long it took them to complete their task. At the end of the intervention, participants were emailed a post-test Qualtrics link that was very similar to the pre-test. The post-test included a 40-item timed (5-minute) math test, the SMS, and the SIMA. Participants were thanked for their participation.

CHAPTER IV

ANALYSIS & RESULTS

The purpose of the study was to closely examine how mindfulness interventions over a short period of time, affects perceived levels of mindfulness and math anxiety. In order to determine the changes in mindfulness and math anxiety we first determined if the construct measures were all working as expected. We used a repeated measures MANOVA to determine if these changes were significant.

Descriptive Statistics

The reliability of the SMS was analyzed using Cronbach's alpha and was found to be quite strong (α = .91). The SIMA is a one-item measure and as such, the internal consistency cannot be determined. The SMI revealed very irregular across the six data collection sessions. The α *if deleted* for the SMI also varies across data collection times. Times 1 and 2 suggest a stronger Cronbach's α if item three was removed. Time 3 suggest a stronger score if the second item were deleted. Item 4 is marked for removal in times 4, 5, and 6. Therefore, the SMI was deemed unreliable and was not used in subsequent analyses.

The pre/post-mindfulness (SMS) and pre/post- math anxiety (SIMA) mean scores and standard deviations are organized by group in Table 1. Descriptive statistics show that all groups increased in their mindfulness scores and decreased in their math anxiety throughout the study, though the largest changes were in the yoga group.

Table 1

Means and SD of Variables for All Groups

	Experimental Groups		
	Control (n=10)	Meditation (n=8)	Yoga (n=7)
Pre-Mindfulness (SMS)	66.46 (10.86)	68.75 (14.12)	61.55 (20.83)
Post-Mindfulness (SMS)	78.08 (11.55)	82.57 (7.91)	76.71 (14.90)
Pre-Math Anxiety (SIMA)	6 (1.73)	5.25 (1.83)	5.50 (2.14)
Post-Math Anxiety (SIMA)	4.50 (2.19)	4.14 (1.86)	3.14 (.90)

Throughout the intervention period, participants had 6 data collection points. The means and standard deviations are displayed in Table 2. Few participants submitted data for every point. We see a decrease in participant data submission for the last collection times. The yoga group registered the greatest attrition in the study.

Table 2

Means, SD, and Sample Sizes by Group across Interventions

Time	Variable	Experimental Groups		
		Control	Meditation	Yoga
Time 1	Mindfulness (SMI)	16.00 (1.54)	15.14 (3.33)	15.66 (2.82)
	Math Anxiety (SIMA)	5.92 (2.02)	6.14 (1.57)	4.11 (2.31)
	n	10	7	9
Time 2	Mindfulness (SMI)	15.58 (3.20)	15.43 (3.15)	15.66 (2.82)
	Math Anxiety (SIMA)	5.33 (2.38)	4.86 (1.86)	4.11 (2.31)
	n	10	7	9
Time 3	Mindfulness (SMI)	15.80 (4.29)	14.43 (2.50)	15.00 (4.54)
	Math Anxiety (SIMA)	4.40 (2.14)	5.00 (1.83)	3.29 (1.70)
	n	10	7	7
Time 4	Mindfulness (SMI)	15.33 (2.06)	14.71 (2.43)	16.28 (2.36)
	Math Anxiety (SIMA)	4.33 (1.66)	4.57 (1.90)	2.71 (1.25)
	n	9	7	7
Time 5	Mindfulness (SMI)	16.60 (1.52)	14.00 (2.45)	15.00 (3.60)
	Math Anxiety (SIMA)	4.80 (1.92)	4.71 (1.70)	2.00 (1.73)
	n	5	7	3
Time 6	Mindfulness (SMI)	15.25 (.96)	15.00 (1.73)	14.5 (3.53)
	Math Anxiety (SIMA)	4.25 (1.50)	2.33 (0.57)	2.50 (0.71)
	n	4	3	2

The main hypothesis for this study was that the mindfulness groups would have significant changes from pre- to post-test in both mindfulness and math anxiety. A repeated measures MANOVA was performed to assess the significance of the changes in the measures of

mindfulness and math anxiety between the three experimental groups. The MANOVA was performed using the change scores from the SMS and the SIMA from the pre-survey and post-survey data. The SMS change and SIMA change were the dependent variables (DVs) and the groups (study/control, meditation, yoga) were the factors. Using Wilks λ, there was not a significant effect of intervention group on the levels of mindfulness and math anxiety over time, Wilks $\lambda = .89$, $F\ (4, 40) = .584$, $p < .05$, $p = .676$. The observed changes in mindfulness and math anxiety over time cannot be attributed to the interventions alone. However, these results should be interpreted with caution due to the large participant attrition. As evidenced in Table 2, less than 50% of each group completed the Time 6 measures. As such, these are not robust interpretations and it is difficult to ascertain the impact of mindfulness interventions on math anxiety.

CHAPTER V

DISCUSSION AND CONCLUSIONS

The practical applications of mindfulness-based interventions have yielded positive outcomes for college students, though the link between mindfulness and math anxiety has yet to be examined closely. The present study was designed to examine the effects of mindfulness interventions on perceived levels of math anxiety and mindfulness levels over a short period of time using EMA-style data collection methods. To answer the original research question we conducted a three-week longitudinal study with three experimental groups. We hypothesized that the mindfulness groups (i.e., meditation and yoga) would show significant increases in mindfulness and decreases in math anxiety and that these groups would be found statistically different from the control (i.e., study skills) group. The findings for all groups suggest average trends showing an increase in mindfulness and a decrease in math anxiety over the course of the intervention. A repeated measures MANOVA revealed that this trend was not significant. Unfortunately, non-significant findings hinder our ability to make any substantial claims about our noted trends.

Though these trends are not statistically significant, they do align with the existing literature on mindfulness and other types of anxiety. There are no known studies that look at the link between mindfulness and math anxiety directly, but a number of studies that examine mindfulness and general anxiety produced positive outcomes. Hayes-Skelton and Wadsworth (2015) clearly described how mindfulness can alleviate the symptoms of anxiety, particularly 1)

broadening the focus from a narrow threat, 2) decreasing rumination and anticipatory anxiety, and 3) focusing on a nonjudgmental attitude. Math anxiety, though not a clinically diagnosed anxiety disorder, does share these symptoms with other forms of diagnosed anxiety. As such, the effectiveness of mindfulness training in individuals with other types of anxiety suggests that it is likely also helpful for those with math anxiety. Because mindfulness teaches focus on awareness, which increases attention (Davis & Thompson, 2015), mindfulness practice can help cultivate coping mechanisms by focusing on the present and combating future- or past-fixated thoughts (Ramasbramanian, 2017; Weis et al., 2020). Math anxious individuals also fixate on past or future thoughts, as well as negative self-talk, which could logically be helped through mindfulness. In addition, mindfulness practices can reduce avoidance behaviors (Carlin & Ahrens, 2012; Hjeltnes et al., 2015), which highly math anxious students are more likely than non-anxious students to engage in (Allen & Jameson, 2021). Mindfulness also improves working memory capacity (Mrazek, et al., 2013) and increases positive attitudes toward math (Bellinger et al., 2015), both of which are contributing factors to the relationship between high math anxiety and low math performance (Ashcraft, 2002; Palestro & Jameson, 2020). It would stand to reason that mindfulness has great potential to help math anxious students. There are several possible explanations why the current study did not find this outcome.

Limitations

Data Collection Issues as a Limitation

The lack of significant findings in our research can be attributed to several unforeseen challenges in data collection. First, the sample size was small, and this can make it challenging to find significant results with small effects. The research was also impacted by attrition (~30%), which is always a concern with longitudinal work but was likely exacerbated by the move to

online courses due to the COVID-19 pandemic. This attrition also led to uneven group sizes; though efforts were made to initially make group sizes equal, the control group had the largest sample size in the end. The combination of small sample size and attrition leading to missing data make it difficult to draw any conclusions about the findings.

We were unable to conduct a true EMA study because user-friendly EMA research applications were neither affordable for the researcher nor accessible for all participants. Though initial data collection began with a free EMA application, some participants did not receive the notifications to participate, which resulted in missing data. Those participants were sent the links via email, but the emails were flagged as spam, resulting in more missing data. Further, though we were attempting to capture mindfulness and math anxiety "in the moment", time stamps from the data reveal that some participants completed multiple days' surveys in one sitting, thus minimizing the role of the "in the moment" measure.

Participant fatigue may have contributed to the attrition and lack of findings as well; there were several measures that participants were asked to complete multiple times per week. We also gave participants a short compliance survey at the end of every week and found that of the participants who completed the compliance check, less than 10% said they had been practicing their intervention activity. Approximately 30% of participants admitted to not completing their intervention tasks on Tuesday or Thursday of the previous week. In addition, participants were asked to watch the same video throughout the weeks. These two factors may have led to participants becoming fatigued at the number of repetitive tasks in the research.

Forming a relationship with instructors may be an important part for teaching mindfulness based practices. Researchers noted that participants' ratings of instructors were predictors of changes in depression and anxiety (Canby et al., 2021). This suggests the social

aspect of in-person classes may be important for students to learn mindfulness practices and gain lasting benefits.

The Construct of Mindfulness as a Limitation

Another possible limitation to the study is the measurement of mindfulness. Mindfulness is a difficult construct to measure, and self-report measures can be inherently unreliable. The operational definition used for mindfulness can vary from study to study depending on which measures are used, resulting in variation across studies in the number and type of factors measured in the available mindfulness scales. As a result, mindfulness measures cover an array of subfactors which seem to indicate that they measure different aspects of mindfulness. For instance, the SMS covers five facets: *observe, describe, nonjudge, act aware,* and *nonreact*; the SMI, on the other hand, only measures mindfulness on *present awareness* and *attention*. Besides the inconsistency in the definition and measurement of mindfulness among researchers, the construct of mindfulness is difficult to measure because of its intrinsic and fluctuating nature. In order to quantify this most researchers have relied on self-report measures, which are open to subjective biases.

Self-report is the primary method used to gauge mindfulness levels. Since mindfulness questionnaires require the participant to be introspective, this measure is vulnerable to response bias as well as other issues associated with asking participants to accurately gauge their own mental faculties (Eklund et al., 2016; Goodman et al., 2017). Some participants may misinterpret the meaning of mindfulness and over-report their actual level of mindfulness. Some participants who have had previous experience with mindfulness practices may actually under-report their mindfulness (Eklund et al., 2016; Harpin et al., 2016). Other methods could be utilized from an

observer point of view, but this would not be able to capture the internal workings of the mind and the essence of the mindful experience.

Another aspect of the construct of mindfulness that may play a role in the lack of significant findings is the broad nature of the interventions used in the study. Goleman and Davidson (2017) propose that there are different levels of mindfulness practice, ranging from Level 1 (i.e., the deepest path and associated with the intense ancient Buddhist practices) to Levels 4 and 5 (i.e., the widest path which is more easily accessible and available on smart phone applications). The mindfulness interventions offered in the current study were more aligned with Level 5 because it was the researcher's intention for the practice to be easily accessible for the participants. Goleman and Davidson also note that for any practice to become effortless, it is important for there to be initial effortful practice (2017). This, combined with the evidence from the compliance check, leads the researcher to consider that the asynchronous and broad interventions used in the current study may simply not have been effective enough to significantly impact participants' mindfulness and anxiety.

Directions for Future Research

Previous research on mindfulness shows its effectiveness at decreasing anxiety and improving learning. The current study, though not statistically significant, does suggest that future research may uncover the impact of mindfulness practice on math anxiety.

Future research should carefully consider the types and levels of intervention used. Considering Goleman and Davidson (2017), comparing interventions across different levels of mindfulness practice may reveal qualitative differences between how level of training impacts math anxiety. Also, the current study consisted of an initial introduction followed by asynchronous practice, but other research consisting of both synchronous and asynchronous

activities using the Koru program successfully increased college students' mindfulness in four weeks (Greenson et al., 2014; Weis et al., 2020). As such, it is clearly possible to increase students' mindfulness using effective techniques. This could lead to future research comparing the type of intervention (e.g., asynchronous only, mixed asynchronous and synchronous, synchronous only) to determine the comparative effectiveness of each intervention type. Also, it has been noted that a variety of mindfulness exercises can help practitioners better apply mindfulness to their daily experience (Goleman & Davidson, 2017). For instance, it is not always appropriate for someone to engage in still meditative or yoga practice, but short breathing exercises are more easily implemented. Perhaps teaching undergraduate students a wider variety of mindfulness techniques for better "in-the-moment" practice would be more effective at reducing math anxiety.

The global pandemic and its ongoing nature also provides opportunity for future research. Weis et al. (2020) used a Koru mindfulness program during the spring semester 2020 at the start of the pandemic, and found that participants were reporting positive effects of the mindfulness interventions up to the end of the semester after the four-week training program. This could be a particularly impactful area of research, given the high stress and anxiety experienced by people due to social isolation, uncertainty, and public health concerns related to the pandemic.

Future research should continue examining the effects of mindfulness practice on math anxiety, particularly using EMA methodology. Both mindfulness and math anxiety are experienced "in-the-moment", and EMA is the ideal method for these types of constructs. Because no known research exists on this topic, but it is a logical relationship given the impact of mindfulness on other types of anxiety, this is a prime area to explore.

Conclusion

Teaching students how to cultivate mindfulness could hold great implications for academic success, particularly within the realm of math anxiety. Attention is an important building block for learning and the basis of mindfulness practice begins with attention. It seems logical to believe that the two working in tandem is the optimal outcome for decreased anxiety and increased learning. Though our results were not statistically significant, our study does serve to extend the literature on mindfulness and its relationship with math anxiety. Further work in this area may find EMA useful for understanding the relationship between math anxiety and different types and levels of mindfulness practice.

References

Allen, M.T. & Jameson, M.M. (2021). How avoidant are math anxious people? Let me count the ways. *Manuscript under revision.*

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185. https://doi.org/10.1111%2F1467-8721.00196

Ashcraft, M.H., & Kirk, E.P. (2001). The relationships among working memory, math and performance. *Journal of Experimental Psychology: General, 130*, 224-237. https://psycnet.apa.org/doi/10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review,* 14*(2),* 243-248. https://doi.org/10.3758/BF03194059

Anxiety. (2018). In *American Psychological Association dictionary*. Retrieved from https://dictionary.apa.org/anxiety.com

Barcaccia, B., Baiocco, R., Pozza, A., Pallini, S., Mancini, F., & Salvati, M. (2019). The more you judge the worse you feel. A judgemental attitude towards one's inner experience predicts depression and anxiety. *Personality and Individual Differences, 138,* 33-39. https://doi.org/10.1016/j.paid.2018.09.012

Basso, J. C., McHale, A., Ende, V., Oberlin, D. J., & Suzuki, W. A. (2019). Brief, daily meditation enhances attention, memory, mood, and emotional regulation in non-experienced meditators. *Behavioral Brain Research, 356*, 208-220. https://doi.org/10.1016/j.bbr.2018.08.023

Beilock, S.L., Gunderson, E.A., Ramirez, G., & Levine, S.C. (2019). Female teachers' math anxiety affects girls' math achievement. *Psychological and Cognitive Sciences, 107*(5), 1860-1863. https://doi.org/10.1073/pnas.0910967107

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. https://doi.org/10.1016/j.concog.2015.09.001

Beauchemin, J., Hutchins, T., & Patterson, F. (2008). Mindfulness meditation may lessen anxiety, promote social skills, and improve academic performance among adolescents with learning disabilities. *Complementary Health Practice Review, 13(*1), 34-45. https://doi.org/10.1177%2F1533210107311624

Bishop, S. R., (2002). What do we really know about mindfulness-based stress reduction? *Psychosomatic Medicine, 64*, 71-84. https://doi.org/10.1097/00006842-200201000-00010

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11(*3), 230-240. https://doi.org/10.1093/clipsy.bph077

Brooks, A. W. (2014). Get excited: Reappraising pre-performance anxiety as excitement. *Journal of Experimental Psychology. General,* 143*(3)*, 1144-1158. https://doi.org/10.1037/a0035325

Bostock, S., Steptoe, A., Crosswell, A. D., & Prather, A. A. (2019). Mindfulness on-the-go: Effects of a mindfulness meditation app on work stress and well-being. *Journal of Occupational Health Psychology, 24*(1), 127-138. https://doi.org/10.1037/ocp0000118

Bostanov, V., Ohlrogge, L., Britz, R., Hautzinger, M., & Kotchoubey, B. (2018). Measuring mindfulness: A psychophysiological approach. *Frontiers in Human Neuroscience, 12*(249), 1-22. https://doi.org/10.3389/fnhum.2018.00249

Brunyé, T. T., Mahoney, C. R., Giles, G. E., Rapp, D. N., Taylor, H. A., & Kanarek, R. B. (2013). Learning to relax: Evaluating four brief interventions for overcoming the negative emotions accompanying math anxiety. *Learning and Individual Differences, 27,* 1–7. 23-132. https://doi.org/10.1016/j.lindif.2013.06.008

Canby, N. K., Eichel, K., Lindahl, J., Chau, S., Cordova, J., & Britton, W. B. (2021). The contribution of common and specific therapeutic factors to mindfulness-based intervention outcomes. *Frontiers in Psychology, 11(603394),* 1-16. https://doi:10.3389/fpsyg.2020.603394

Carlin, A. C., & Ahrens, A. H. (2012). The effects of mindfulness and fear-inducing stimuli on avoidance behavior. *Mindfulness, 5,* 276-281. https://doi:10.1007/s12671-012-0177-3

Clark, J. K., Thiem, K. C., Hoover, A. E., & Habashi, M. M. (2017). Gender stereotypes and intellectual performance: Stigma consciousness as a buffer against stereotype validation. *Journal of Experimental Social Psychology, 68,* 185-191. https://doi.org/10.1016/j.jesp.2016.07.002

Crede, M., & Kuncel, N. R. (2008). Study habits, skills, and attitudes: The third pillar supporting collegiate academic performance. *Perspectives on Psychological Science, 3*(6), 425-445. https://doi.org/10.1111%2Fj.1745-6924.2008.00089.x

Davis, J. H., & Thompson, E. (2015). Chapter 3: Developing attention and decreasing affective bias. In Brown, K. W., Creswell, J. D., & Ryan, R. M. (Ed.), *Handbook of Mindfulness: Theory, Research, and Practice*, The Guilford Press

de Jong, T. (2010). Cognitive load theory, educational research, and instructional design: some food for thought. *Instructional Science, 38,* 105-134. https://doi:10.1007/s11251-009-9110-0

Desai, R., Tailor, A., & Bhatt, T. (2015). Effects of yoga on brain waves and structural activation: A review. *Complementary Therapies in Clinical Practice, 21,* 112-118. https://doi:10.1016/j.ctcp.2015.02.002

Eklund, K., O'Malley, M., & Meyer, L. (2016). Gauging mindfulness in children and youth: School-based applications. Psychology in the Schools, 54(1), 101-113. https://doi:10.1002/pits.21983

Friese, M., & Hofmann, W. (2016). State mindfulness, self-regulation, and emotional experience in everyday life. *Motivation Science, 2*(1), 1-14. https://doi:10.1037/mot0000027

Flook, L., Smalley, S. I., Kitil, M. J., Galla, B. M., Kaiser-Greenland, S., Locke, J., Ishijima, E., & Kasari, C. (2010). Effects of mindful awareness practices on executive functions in elementary school children. *Journal of Applied School Psychology, 26,* 70-95, https://doi:10.1080/15377900903379125

Galatino, M. L., Galbavy, R., Quinn, L. (2008). Therapeutic effects of yoga for children: A systematic review of the literature, *Pediatric Physical Therapy*, 66-80. https://doi:10.1097/PEP.0b013e31815f1208

Ganley, C. M., & Vasilyeva, M. (2014). The role of anxiety and working memory in gender differences in mathematics. *Journal of Educational Psychology, 106(*1), 105-120. https://doi:10.1037/a0034099

Gogol, K., Brunner, M., Preckel, F., Goetz, T., & Martin, R. (2016). Developmental dynamics of general and school-subject-specific components of academic self-concept, academic interest, and academic anxiety. *Frontiers in Psychology, 7(*356), 1-15. https://dx.doi.org/10.3389%2Ffpsyg.2016.00356

Goleman, D., & Davidson, R. J. (2017). *Altered traits: Science reveals how meditation changes your mind, brain, and body.* Penguin Random House

Goodman, M. S., Madni, L. A., & Semple, R. J. (2017). Measuring mindfulness in youth: Review of current assessments, challenges, and future directions. Mindfulness, 8, 1409–1420. https://doi.org/10.1007/s12671-017-0719-9

Greenson, J. M., Juberg, M. K., Maytan, M., James, K., & Rogers, H. (2014). A randomized controlled trial of Koru: A mindfulness program for college students and other emerging adults. *Journal of American College Health, 67*(4), 222-233. https://doi.org/10.1080/07448481.2014.887571

Hagen, I., & Nayar, U.S. (2014). Yoga for children and young people's mental health and well-being: research review and reflections on the mental health potentials of yoga. *Frontiers in Psychiatry, 5*(35), 1-6. https://doi:10.3389/fpsyt.2014.00035

Harpin, S. B., Rossi, A. M., Kim, A. K., & Swanson, L. M. (2016) Behavioral impacts of a mindfulness pilot intervention for elementary school. Education, 137(2), 149-156. https://doi.org/10.1007/s12671-020-01317-6

Hayes-Skelton, S. A., & Wadsworth, L. P. (2015). Chapter 20: Mindfulness in the treatment of anxiety. In Brown, K. W., Creswell, J. D., & Ryan, R. M. (Ed.), *Handbook of Mindfulness: Theory, Research, and Practice*, The Guilford Press.

Hendy, H. M., Schorschinsky, N., & Wade, B. (2014). Measurement of math beliefs and their associations with math behaviors in college students. *Psychological Assessment, 26(*4), 1225-1234. https://doi:10.1037/a0037688

Hoare, C. (Ed.). Barner, C. P., & Barner, R. W. (2011). Mindfulness, Openness to Experience, and Transformational Learning, In *The Oxford Handbook of Reciprocal Adult Development and Learning* (2nd ed., pp. 1-29). Oxford University Press.

Hunt, M., Al-Braiki, F., Dailey, S., Russell, R., & Simon, K. (2018). Mindfulness training, yoga, or both? Dismantling the active components of a mindfulness-based stress reduction intervention. *Mindfulness, 9,* 512-520. https://doi:10.1007/s12671-017-0793-z

Hjeltnes, A., Binder, P., Moltu, C., & Dundas, I. (2015). Facing the fear of failure: An explorative qualitative study of client experiences in a mindfulness-based stress reduction program for university students with academic evaluation anxiety. *International Journal of Qualitative Studies on Health and Well-being, 10*(27990), 1-14. https://doi.org/10.3402/qhw.v10.27990

Jameson, M.M. (2020). Time, time, time: Perceptions of the causes of mathematics anxiety in highly maths anxious female adult learners. *Adult Education Quarterly, 70*(3), 223-239. https://doi.org/10.1177/0741713619896324

Jameson, M. M., & Fusco, B. R. (2014). Math anxiety, math self-concept, and math self-efficacy in adult learners compared to traditional undergraduate students. *Adult Education Quarterly, 64(4),* 306-322. https://doi.org/10.1177%2F0741713614541461

Jansen, B. R. J., Louwerse, J., Straatemeier, M., Ven, v. d., S.H.G, Klinkenberg, S., & Maas, v. d., H.L.J. (2013). The influence of experiencing success in math on math anxiety, perceived math competence, and math performance. *Learning and Individual Differences, 24,* 190-197. https://doi:10.1016/j.lindif.2012.12.014

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

Karimi, A., & Venkateson, S. (2009). Cognitive behavior group therapy in mathematics anxiety. *Journal of the Indian Academy of Applied Psychology*, *35*(2), 299-303.

Lefevre, J., Kulak, A. G., & Heymans, S. L. (1992). Factors influencing the selection of university majors varying in mathematical content. *Canadian Journal of Behavioural Science/Revue Canadienne Des Sciences Du Comportement, 24*(3), 276-289. https://doi:10.1037/h0078742

Lutz, A., Slagter, H.A., Dunne, J.D., & Davidson, R.J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences, 12*(4), 163-169. https://doi:10.1016/j.tics.2008.01.005

Lyons, I. M., & Beilock, S. L. (2012). When math hurts: Math anxiety predicts pain network activation in anticipation of doing math. *PloS One, 7(10),* e48076. https://doi.org/10.1371/journal.pone.0048076

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520-540.

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

Moran, T. P. (2016). Anxiety and working memory capacity: A meta-analysis and narrative review. *Psychological Bulletin, 33*(16), 1-24. https://doi:10.1037/bul0000051

Mrazek, M. D., Franklin, M. S., Phillips, D. T., Baird, B., & Schooler, J. W. (2013). Mindfulness training improves working memory capacity and GRE performance while reducing mind wandering. *Psychological Science*, *24*(5), 776-781. https://doi:10.1177/0956797612459659

Nairne, J. S. (2006). *Psychology* (4th ed.). Belmont, CA: Thompson Wadsworth.

Nilsson, H. & Kazemi, A. (2016). From Buddhist sati to Western mindfulness practice: A contextual analysis. *Journal of Religion & Spirituality in Social Work: Social Thought, 35(*1-2), 7-23. https://doi:10.1080/15426432.2015.1067582

Nunez-Pena, M. I., Guilera, G., & Suarez-Pellicioni, M. (2014). The single-item math anxiety scale: An alternative way of measuring mathematical anxiety. *Journal of Psychoeducational Assessment*, *32(*4), 306-317. https://doi:10.1177/0734282913508528

Owens, M., Steveson, J., Hadwin, J. A., & Norgate, R. (2012). When does anxiety help or hinder cognitive test performance? The role of working memory capacity. *British Journal of Psychology*, *105*, 92-101. https://:10.1111/bjop.12009

Palestro, J.J. & Jameson, M.M. (2020). Math self-efficacy, not emotional self-efficacy, mediates the relationship between math anxiety and performance in college students. *Cognition, Brain, & Behavior, 24*, 379-394.

Pizzie, R. G., & Kraemer, D. J. M. (2019). The academic anxiety inventory: Evidence for dissociable patterns of anxiety related to math and other sources of academic stress. *Frontiers in Psychology, 9*(2684), 1-20. https://doi:10.3389/fpsyg.2018.02684

Quaglia, J. T., Brown, K. W., Lindsay, E. K., Creswell, J. D., & Goodman, R. J. (2015). From conceptualization to operationalization of mindfulness. In Brown, K. W., Creswell, J. D., & Ryan, R. M. (Ed.), *Handbook of Mindfulness: Theory, Research, and Practice*, The Guilford Press.

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

Ramasbramanian, S. (2017). Mindfulness, stress coping and everyday resilience among emerging young in a university setting: A mixed methods approach. *International Journal of Adolescence and Youth, 22*(3), 308-321. https://doi:10.1080/02673843.2016.1175361

Richmond, K., Zerbo, E., & Levounis, P., (2017). What is mindfulness? A history of mindfulness and meditation. *Becoming Mindful,* Arlington, VA: American Psychiatric Association Publishing

Ruscio, A. C., Muench, C., Brede, E., McIntyre, J., & Waters, A. J. (2016). Administration and assessment of brief mindfulness practice in the field: A feasibility study using ecological momentary assessment. *Mindfulness, 7*, 988-999. https://doi:10.1007/s1267-016-0538-4

Shapiro, S. L., Lyons, K. E., Miller, R. C., Butler, B., Vieten, C., & Zelazo, P. D. (2015). Contemplation in the classroom: A new direction for improving childhood education. *Educational Psychology Review, 27*, 1–30. https://doi:10.1007/s10648-014-9265-3

Silk, J. S., Tan, P. Z., Ladouceur, C. D., Meller, S., Siegle, G. J., McMakin, D. L., Forbes, E. E., … (2018). A randomized clinical trial comparing individual cognitive behavioral therapy and child-centered therapy for child anxiety disorders. *Journal of Clinical Child & Adolescent Psychology*, *47*, 542-554. https://doi:10.1080/15374416.2016.1138408

Sirois, F. M., & Tosti, N. (2012). Lost in the moment? An investigation of procrastination, mindfulness, and well-being. *Journal Rational-Emotional Cognitive Behavioral Theory, 30*, 237-248. https://doi:10.1007/s10942-012-0151-y

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, *35(*1), 4-28. https://doi:10.1006/jesp.1998.1373

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*, 295-312. https://doi.org/10.1016/0959-4752(94)90003-5

Tanay, G., & Bernstein, A. (2013). State Mindfulness Scale (SMS): Development and initial validation. *Psychological Assessment, 25*(4), 1286-1299. https://doi:10.1037/a0034044

Tobias, S. (1979). Anxiety research in educational psychology. *Journal of Educational Psychology*, *71*(5), 573-582. https://psycnet.apa.org/doi/10.1037/0022-0663.71.5.573

Urbanowski, F. B., & Miller, J. J. (1996) Trauma, psychotherapy, and meditation. *Journal of Transpersonal Psychology*, *28*(1), 31-48.

Viglas, M., & Perlman, M. (2018). Effects of a mindfulness-based program on young children's self-regulation, prosocial behavior and hyperactivity. *Journal of Child Family Studies, 27*, 1150–1161. https://doi:10.1007/s10826-017-0971-6

Vohra-Gupta, S., Russell, A., & Lo, E. (2007). Meditation: The adoption of eastern thought to western social practices. *Journal of Religion and Spirituality in Social Work, 26*(2), 49-61. https://doi:10.1300/J377v26n02_03

Weis, R., Ray, S. D., & Cohen, T. A. (2020). Mindfulness as a way to cope with COVID-19-related stress and anxiety. *Counseling Psychotherapy Research, 21*, 8-18. https://doi.org/10.1002/capr.12375

Wilkinson, G. S., & Robertson, G. J. (2006). Wide Range Achievement Test 4 (WRAT4) [Database record]. APA PsycTests. https://doi.org/10.1037/t27160-000

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

Zirkel, S., Garcia, J. A., & Murphy, M. C. (2015). Experience-sampling research methods and their potential for education research. *Educational Researcher,* 1-10. https://doi:10.3102/001389X14566879

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	January 24, 2020
TO:	Elysia Garza
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[1532928-2] Brief Mindfulness Interventions and Math Anxiety using Ecological Momentary Assessment
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVAL/VERIFICATION OF EXEMPT STATUS
DECISION DATE:	January 24, 2020
EXPIRATION DATE:	January 24, 2024

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Nicole Morse at 970-351-1910 or nicole.morse@unco.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.