UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

USING AN ONLINE-BASED MINDFULNESS INTERVENTION TO REDUCE TEST ANXIETY IN UNIVERSITY STUDENTS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY in partial fulfillment for the

Degree of

DOCTOR OF PHILOSOPHY

By

John Brandon Chancey

Norman, OK

2020

USING AN ONLINE-BASED MINDFULNESS INTERVENTION TO REDUCE TEST ANXIETY IN UNIVERSITY STUDENTS

A DISSERTATION APPROVED FOR THE DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

BY THE COMMITTEE CONSISTING OF

Dr. Benjamin Heddy, Chair

Dr. Teresa Debacker

Dr. Mike Crowson

Dr. Ji Hong

Dr. Crag Hill

DEDICATION

I dedicate this work to my parents, Ron and Karen, my siblings, Alyssa, Jacob and Kayla, and my best friend and partner, Lauren Gill. This would not be possible without your guidance, love, and support.

ACKNOWLEDGEMENTS

Completing a PhD is no small feat. While I am grateful for my own effort and ability put into completing this task, I could not have made it this far in my education without the love and support I received from several individuals over the last four years.

First and foremost, I would like to acknowledge and thank my advisor, mentor, and friend Dr. Ben C. Heddy. When it comes to research, I was about as green as they come entering my PhD studies. However, Dr. Heddy saw potential in me that I was unable to see in myself. He constantly pushed me outside of my comfort zones both personally and intellectually. I am proud to say that because of his support and guidance, I not only completed my PhD, but was able to secure a job as an assistant professor in Fall 2020. I could not have succeeded without his constant feedback and motivation. Thank you, Ben, for helping me become closer to the best version of myself.

Second, I would like to acknowledge my colleagues in this program and elsewhere for the feedback and support including Dr. Mike Nelson, Diana Meek, Dr. Alex Parsons, Kelly Ross, Dr. Ben Torsney, Murat Turk, Dr. Ian Thacker, Tim Klavon, Neil Jacobson and Dr. John Park. I also want to acknowledge and thank my dissertation committee: Dr. Mike Crowson, Dr. Teresa DeBacker, Dr. Ji Hong, and Dr. Crag Hill. Each of these individuals provided me with invaluable feedback and encouragement at various points of writing my dissertation. I cannot begin to thank them enough

Next, I would like to acknowledge my workout coach, BJ Gaddour, for pushing me physically in ways that gave me the confidence and courage to finish my dissertation. I was able

to take that the intensity from your workouts and apply them to the process of producing this document. BJ's workouts were a crucial piece in becoming a man of knowledge.

Finally, I would like to acknowledge and deeply thank my family, friends, and loved ones for all of their love and support during this entire process. In particular, I would like to acknowledge my best friend and partner, Lauren Gill, and my parents, Ron and Karen, who have given me so much love and support throughout my entire life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study investigated the theoretical and practical relationship between mindfulness and test anxiety. I explored this relationship with college students enrolled in an Introductory Physics II course at a large university in the American Southwest. The goal of this research was twofold: first to explore the theoretical relationship between mindfulness, emotional regulation, attentional regulation, and test anxiety. Second, to examine the effectiveness of using an online-based mindfulness intervention to reduce test anxiety in college students. Results suggest that emotional regulation had very little predictive power while attentional regulation was a strong significant predictor of test anxiety. Additionally, the eight week mindfulness intervention resulted in non-significant changes in test anxiety and quiz scores for the treatment compared to the control. These findings have both theoretical and practical implications.

CHAPTER ONE

OVERVIEW OF THE STUDY

The aim of this study was twofold: 1) explore the theoretical relationship between the constructs of mindfulness and test anxiety and 2) explore the impact of an online mindfulness intervention on the test anxiety of college students enrolled in an Introductory Physics class. Investigating mindfulness as a concept is on the rise in psychological science literature but remains difficult to define. Mindfulness is typically defined as present moment awareness without judgement (Kabbat-Zinn, 2003), but that construct definition is perhaps too abstract to be grounded in theories of educational psychology.

The first goal of this research was to define mindfulness in terms of constructs related to educational psychology in order to investigate how mindfulness can be useful in educational contexts. In this case, I explored the construct of mindfulness through the lens of emotional and attentional regulation as the primary mechanisms for facilitating the experience of mindfulness. Based on my understanding of the research literature, I postulate that these are the two mechanisms that drive the bus to enhance the experience of mindfulness.

In addition to the theoretical outcomes, the second goal of this research was to determine whether an online-based mindfulness intervention can be used to reduce test anxiety in college students enrolled in an Introductory Physics course. I have not encountered research that specifically suggests Introductory Physics courses carry more test anxiety than other courses. However, there could be an argument that Introductory Physics courses are associated with a high amount of test anxiety because students in these courses are challenged to think scientifically, perhaps for the first time in their academic career (Redish, Saul, & Steinberg, 1998).

I created an eight-week online based intervention to address test anxiety aimed at cultivating the development of mindfulness. The intervention was modeled after Morledge and colleagues (2013) for online mindfulness interventions by including at least eight weeks of intervention length and providing participants with tips and readings on how to practice mindfulness. Additionally, research by Lippmann and colleagues (2018) suggests that online mindfulness interventions can be most effective when the intervention is designed to address specific psychological conditions and include both formal and informal opportunities to practice. I will use this introduction to explain the problem being addressed by this research. I then describe the purpose of this study. Finally, I explicitly define each relevant construct for this study before moving on to the next chapter.

Problem Statement

Students at all levels of education are subject to assessment and that does not appear to be changing any time soon. Assessment is the primary method for measuring student success. Some students appear to experience strong emotions such as anxiety in the face of assessment that may have detrimental effects on their ability to perform in achievement situations (Huberty, 2009). While anxiety is a part of the typical human emotional experience, test anxiety goes above and beyond normal levels of anxiety. Test anxiety happens when students experience high levels of stress, nervousness, or apprehension related to achievement situations (Salend, 2010). Test anxiety is experienced by individuals through a unique combination of physical (ex. nausea, rapid heartbeat), behavioral (ex. difficulty maintaining attention, pretending to be ill), and affective symptoms (ex. lack of motivation, making negative comparisons to other students) that make test tasking more difficult for those students (Salend, 2010).

Test anxiety is problematic for assessing learning outcomes because chronic test anxiety is associated with poor educational outcomes, reduced self-esteem, reduced effort, and increased apathy towards completing schoolwork (Huberty, 2009). Compared to their peers with low test anxiety, students with high test anxiety do not perform as well in achievement situations (Huberty, 2009). Additionally, test anxiety is not contained exclusively to achievement situations, but test anxiety is also experienced as learners prepare for assessment or evaluate their own performance after assessment (Cassady, 2004). This is also problematic for learners because intense emotions like test anxiety may prevent learners from preparing adequately for examination or reflecting on how to improve future assessment performance once assessment has concluded. A conservative estimate suggests that at least a third of college students experience test anxiety (Huberty, 2009). The experience of test anxiety is also greater for students with learning disabilities (Peleg, 2009), ethnically diverse students (Carter, Williams, & Silverman, 2008), and females (Gerwing et al, 2005).

Fortunately, college students can be taught specific strategies to manage strong emotional experiences like test anxiety that occur in classrooms. One specific strategy that could potentially be used by college students to reduce test anxiety is practicing mindfulness (Kabbat-Zinn, 2003). Teaching students the skills of mindfulness could help address this problem by providing learners who experience greater levels of test anxiety with a concrete set of cognitive and behavioral strategies that can be used in and out of the classroom to proactively combat intense emotions like test anxiety. I posit that this can be achieved through activities that teach students how to better regulate their attention and emotions. Mindfulness can potentially be used to accomplish both goals. Common symptoms of test anxiety include mind wandering and rumination on negative thoughts and emotions (Kamel, 2018). Teaching college students how to

remain grounded in the present moment with mindfulness will help students remain engaged in the present moment during exams when their minds might begin to wonder or become distracted by negative thoughts.

Purpose of the Study

The purpose of this research was to explore the theoretical relationship between mindfulness and test anxiety. Additionally, another purpose of this research was to explore the impact of using an online mindfulness intervention to reduce test anxiety in college physics students. To do this, I surveyed students enrolled in an Introductory Physics course three times during the semester (T1, T2, T3) eight weeks apart from start to finish. Students were assessed for the constructs of mindfulness, test anxiety, emotional regulation, and attentional regulation. I used the data collected at T1 to study the relationships among the measured variables to answer the following research question:

- What is the predictive relationship between emotional regulation, attentional regulation, mindfulness and test anxiety?

Additionally, I created and implemented an eight week online-based mindfulness intervention for those same students. The goal of this intervention was to use specific cognitive-based mindfulness strategies to reduce the experience of test anxiety and ultimately lead to subsequent success in academic performances. Based on a review of relevant literature, my knowledge of the topic, and analysis of the problem, the following research questions guided my inquiry:

- Will an internet-based mindfulness intervention facilitate a reduction in test anxiety more than a control?

The first hypothesis was that the primary mechanisms for facilitating the development of mindfulness occur by enhancing an individual's ability to regulate their attention and emotions, respectively. Previous research suggests that participating in mindfulness-based interventions can have positive effects on the ability to regulate one's emotions (Maloney, Lawlor, Schonert-Reichl, & Whitehead, 2016) and attention towards the present moment (Jha, Krompinger, & Baime 2007). My prediction was that mindfulness is associated with a heightened ability to stay grounded emotionally in the present moment, meaning individuals who are more mindful will have an easier time regulating intense emotional experiences such as test anxiety**.**

Theoretically, I predicted that the mechanisms of attentional and emotional regulation through mindfulness would reduce the experience of test anxiety. Individuals who are more mindful will have greater awareness of their emotional experiences in the present moment, including the impermanent nature of each emotional experience. Additionally, I predicted that these individuals will also have greater awareness of when their attention has wandered from the present moment and be able to bring it back to the present moment. Research by Jha, and colleagues (2007) suggests that practicing mindfulness improves aspects of attention such as sustaining attention in the face of distracting stimuli. This is relevant for test anxiety because it is typical for individuals dealing with test anxiety to have a hard time maintaining their attention because of competing stimuli such as distracting thoughts (Salend, 2010).

The second hypothesis was that participating in an eight week online mindfulness intervention would reduce the experience of test anxiety in college students enrolled in a physics class compared to a control group that did not receive mindfulness training. Previous research by Cho and colleagues (2016) used a single week mindfulness self-guided intervention to reduce test anxiety with positive results, however they only worked with students who registered high

test anxiety and did not measure mindfulness directly, but instead measured the construct of reappraisal. I predicted that an online-based mindfulness intervention would be most helpful for those students enrolled in physics with high test anxiety, but also for individuals even with small to moderate amounts of test anxiety. I chose to include an eight week intervention length because that is the closest thing to a consensus for the use of online mindfulness-based interventions (Morledge et al, 2015).

To explore these research questions, I used a pre and post quasi-experimental design, by comparing a treatment group that receives mindfulness training and a control group that does not. I have gained access to a Physics II college course at a large public university in the American Southwest. Members of this class were asked to complete surveys on mindfulness, emotional regulation, attentional regulation, and test anxiety at three different times of the semester (pre, middle, and post). I also had access to student exam grades to explore the academic impact of reducing test anxiety. Participants were also given the chance to participate in an eight week online mindfulness intervention intended to address their test anxiety. Data was analyzed using a combination of repeated measures ANOVA and path analysis structural equation modeling (SEM) to answer each of the research questions.

Significance of the Study

My research begins to fill a gap in the research literature on mindfulness interventions used in educational settings by implementing an eight week online-based mindfulness intervention to specifically target test anxiety with college students enrolled in an introductory physics course through the mechanisms of attentional regulation and emotional regulation. Previous research by Cho and colleagues (2019) used a self-guided mindfulness intervention to target student test anxiety, but their intervention was self-taught rather than scaffolded by an

expert and delivered online. Additionally, these researchers did not measure the construct of mindfulness directly. Research by Lippman and colleagues (2018) suggests that online-based mindfulness interventions can be used effectively to address specific psychological symptoms, such as stress and anxiety, but only if participants are given both formal and informal opportunities to practice and develop the skills necessary to see positive effects of mindfulness. The goal of this intervention research was twofold: 1) to explore the theoretical relationships between the constructs of mindfulness, emotional regulation, attentional regulation, and test anxiety and 2) to examine the impact of an online mindfulness-based intervention with introductory physics students.

Results from path analysis used to address question one suggests that variables of attentional regulation, the two factors of mindfulness - awareness and acceptance were strong, significant predictors of both test anxiety and grades at T1. Compared to attentional regulation, emotional regulation on the other hand, had very little predictive power for test anxiety or grades at T1. These results have theoretical implications for how mindfulness-based interventions should be structured in educational settings.

Results from repeated measures analysis used to address question two revealed that participants in the mindfulness condition had a non-significant effect on reducing test anxiety. Results of these analyses have practical implications for how mindfulness interventions should be used and developed in classroom settings.

Each of these implications are described in more detail in Chapter Five. The outline of this proposal is as follows: I start by defining the constructs relevant to the proposal including mindfulness and test anxiety. Afterwards, I describe how these two constructs are related.

DEFINITION OF TERMS

The following section is intended to provide definitions for the key terms used in this dissertation research.

Mindfulness: Kabat-Zinn (2003) provides one of the most widely cited definitions of mindfulness. He defines mindfulness as *present moment awareness with an attitude of open-awareness and non-judgement*. However, I believe that this definition leaves something to be desired in terms of understanding what mechanisms allow for non-judgmental present moment awareness. Bishop and colleagues' (2004) construct definition of mindfulness may be a better starting point for defining mindfulness because this definition taps into the underlying mechanisms used for achieving a state of mindfulness. These authors define mindfulness as a two-component construct including 1) self-regulation of attention towards the present moment and 2) an open curiosity towards what happens in the present moment. These two subcomponents appear to be in line with existing constructs from educational psychology - emotional regulation and attentional regulation, respectively. Each will be defined in this section. For the purpose of this study, I am operationally defining mindfulness as a distinct cognitive state of engagement in the present moment associated with attentional and emotional regulation.

Test anxiety: Test anxiety is defined as a heightened feeling of nervousness or anxiety in the face of assessment (Salend, 2010). Additionally, test anxiety is defined by a unique combination of physical, behavioral, and affective symptoms (Salend, 2010). Test anxiety is also experienced by students before and after taking an exam (Cassady, 2004). In this study I explored the construct of test anxiety through Cassady and Johnson's (2001) Test Anxiety Inventory. This instrument focuses on the cognitive nature of test anxiety.

Emotional Regulation: Emotional regulation is defined as the ability to exert control over the emotions an individual experiences (Gross, 2015). Emotions can be regulated in terms of their intensity, duration, and quality. Emotional regulation belongs to a broad range of strategies used for regulating affect (Gross & Thompson, 2007). According to Gross and Thompson (2007) there are five broad strategies that individuals can use to regulate their emotions - situation selection, situation modification, attentional deployment, cognitive change, and response modulation.

Attentional Regulation: Attentional regulation is defined as the ability to orient attention to external objects and to manage streams of thought (Posner & Dehaene, 1994). Bishop and colleagues (2004) argue that mindfulness promotes three specific components of attentional regulation: 1) sustaining attention in the present moment; 2) attention switching between competing stimuli; and 3) inhibition of elaborative processing that could distract attention.

Physics Education: In this study physics education was represented by college level physics courses. I focused on introductory college physics courses at a large public university in the American Southwest (Ex. Introductory Physics I and II).

In the remainder of this dissertation, I begin by thoroughly defining the construct of mindfulness in non-educational and educational contexts, specifically how mindfulness promotes both attentional regulation and emotional regulation. Next, I provide a brief theoretical and empirical overview on the topic of test anxiety. I conclude the literature review by exploring how the construct of mindfulness could theoretically influence test anxiety. Afterwards, I describe how using an online mindfulness intervention could be used to reduce test anxiety. I then state my research questions that were used to drive this investigation, including predicted outcomes. I also included the design, procedures, analysis, and results of the research. Finally, I

conclude my dissertation with a discussion of the impact, limitations, and future directions for this research.

CHAPTER TWO

BACKGROUND LITERATURE

What is Mindfulness?

Mindfulness is a construct that has exploded into the field of education (Schonert-Reichl & Roeser, 2016). Peer reviewed publications and National Institute of Health (NIH) grants related to research on mindfulness have grown significantly (Roeser & Zelaro, 2012). Despite the wide usage of this term, confusion still exists on how to operationally define mindfulness as a construct.

Kabat-Zinn (2003), who is regarded as the founder of the western movement towards mindfulness, coined the most widely used and cited construct definition of mindfulness. Kabat-Zinn, through his creation of Mindfulness-Based Stress Reduction (MBSR), defines mindfulness as *present moment awareness with an attitude of open-awareness and non-judgement.* This definition of mindfulness, however, leaves some unanswered questions. For instance, the literature does not operationally define present moment awareness. Therefore, with a lack of full operational definition, mindfulness as a construct remains abstract.

However, tangible examples exist that could offer a concrete definition of mindfulness. Physical manifestations of practicing mindfulness, such as sitting meditation and various forms of yoga may prove helpful in understanding this construct more concretely. Mindfulness is strongly associated with formal meditative practices such as breathing meditation (Gunaratana, 2002). Using the breath as an anchor to achieve a state of mindfulness leads to the development of mental skills, that over substantial time and formal and informal practice will gradually change an individual's default mode of cognition from initially reactive to reflective (Germer, 2004). Informal mindfulness practices include any activities that involve maintaining mindful

awareness in the moment, including walking, eating or washing the dishes. Examples of formal mindfulness practices include breathing meditation and yoga (Stahl & Goldstein, 2010). Breathing meditation will be the primary method used for cultivating mindful awareness in this dissertation intervention, and thus distinguishing different types of breathing meditation is important.

According to Lutz, Slagter, Dunne, and Davidson (2008), breathing meditation can be divided into one of two broad categories that both promote the cultivation of mindfulness: focused attention and open-monitoring meditation. Focused attention meditation involves directing all of one's cognitive effort towards a singular object such as the breath or a mantra and returning one's attention to this singular object anytime attention wanders from the object. Open-monitoring meditation, on the other hand, is a process of mindfully observing all experiences as they occur without emotional reactivity. For example, both of these forms of mindfulness meditation can be seen as different tools from a cognitive toolbox used to cultivate the skill set of mindfulness. However, even with these physical examples of mindfulness, there are still important questions yet to be answered when defining mindfulness. Specifically, what are the subcomponents involved in evoking a state of present moment awareness?

Understanding the subcomponents used to achieve a mindful state is important for mindfulness research in educational psychology because applying the construct of mindfulness through educational interventions that use mindfulness is perhaps limited without a definition grounded in educational psychology. Bishop and colleagues' (Bishop et al., 2004) construct definition of mindfulness may shed some light on the underlying mechanisms, or subcomponents, used for achieving a state of mindfulness that can be traced back to constructs from educational psychology. Bishop and colleagues (2004) define mindfulness as a two-

component construct. Those components include: 1) self-regulation of attention towards the present moment and 2) an open curiosity towards what happens in the present moment. These components can be summed up into cognitive and affective dimensions, respectively. In order to achieve a mindful state, cognition must be directed toward the present using self-regulation that results in emotional balance. Furthermore, Bishop and colleagues (2004) operationally define mindfulness as an acquirable skill that can be cultivated with enough practice. According to Bishop and colleagues (2004), being mindful involves directing attention on the immediate cognitive experience while maintaining an orientation of openness, curiosity, and acceptance to whatever experiences arise in the present moment. Now that mindfulness is defined, I will explore the use of mindfulness-based interventions in non-academic settings.

Mindfulness-based interventions in non-academic settings

Participating in mindfulness-based interventions (MBIs) is associated with a number of positive outcomes. MBIs have been used successfully with clinical populations to treat psychological disorders such as eating disorders (Kristeller, 2015) addiction (Brewer, Van Dam & Davis, 2015) and post-traumatic stress disorder (Lukoff & Strozzi-Heckler, 2017). In addition to clinical populations, applying MBIs with non-clinical populations appears to be positively related to a number of affective benefits including achieving a state of emotional acceptance (Teper & Inzlicht, 2012), improving the quality of interpersonal relationships (Brown & Ryan, 2003; Baer, Smith, and Allen, 2004), and being more empathetic towards self and others (McKibben, 2014). A common emotional response that results from participating in MBIs includes improvement in overall emotional well-being (Schultz et al., 2015). Research by Lawlor (2016) suggests that practicing mindfulness promotes both cognitive and non-cognitive skills

studied through social emotional learning. For example, mindfulness can teach individuals the skills of compassion and empathy for others.

Additionally, participating in mindfulness-based interventions (MBIs) is associated with a number of positive outcomes related to anxiety reduction. For example, research by Kiken and Shook (2012) found that mindfulness training resulted in a reduction in self-reported emotional distress. MBIs have also been found effective in treating anxiety and depression for both clinical and non-clinical populations (Edenfield & Saaed, 2012). Zoogman and colleagues (2019) found that an intervention using yoga (mindful movements) had a large statistical effect for reducing the symptoms of anxiety. Practicing mindfulness also has the potential to change the way the brain processes intense emotions like anxiety. Research by Shanok and colleagues (2019) applied a 10-week daily mindfulness training intervention with children ages seven to ten. EEG readings showed a decrease in brain activity responsible for the experience of anxiety such as the amygdala. Mindfulness training may also be as effective at reducing anxiety as other existing strategies and is perhaps more cost effective. Goldin and colleagues (2016) found that participation in a mindfulness-based stress reduction program was as effective in treating non-clinical social anxiety as cognitive behavioral therapy.

Mobile Applications

The growth and development of mobile phone apps has opened the door for online-based mindfulness interventions. Research by Lippman, Heinzle, and Narciss (2018) suggests that online-based mindfulness interventions contain opportunities for users to engage in both formal and informal practice. These interventions are most effective when they last for at least eight weeks in duration and can be highly effective when those interventions are aimed at specific psychological symptoms (Lippman et al, 2018). In order to help motivate participants to

remember to practice mindfulness, Morledge and colleagues (2013) used email reminders to prompt participants to engage in mindfulness practices over the course of an eight week intervention intended to help participants with stress. Results of their research revealed the feasibility of using an online-based mindfulness intervention to reduce participant stress. Research by Younge and colleagues (2015) shows that mindfulness-based interventions that incorporate elements of internet/mobile technology can also be used for the treatment of heart disease.

What is mindfulness in education?

As familiarity with mindfulness has grown in numerous settings including schools, secular forms of mindfulness-based interventions (MBIs) have been developed and used in a wide variety of school settings (Schonert-Reichel & Roeser, 2016). Mindfulness-based research suggests that MBIs can be successfully incorporated into a wide variety of educational settings and institutions using populations that range in age and development from elementary education classrooms (Diamond & Lee, 2011; Flook, Goldberg, Pinger & Davidson, 2015), secondary education classrooms (Schonert-Reichl & Lawlor, 2010), to post-secondary/collegiate classrooms (Goodman, Kashdan, Mallard, & Schumann, 2014). MBIs may also be beneficial for both parents and educators of students with special needs to improve the quality of parenting (Benn, Akiva, Arel, & Roeser, 2012).

For the context of this intervention research, *I am operationally defining mindfulness as a distinct cognitive state of engagement in the present moment associated with attentional and emotional regulation.* This conceptual definition uses a combination of Bishop and colleagues' (2004) two component definition (attentional and emotional regulation) along with Roeser and Pinela's (2014) understanding of contemplative practices which are defined as a range of

practices that are used for the intent of cultivating present minded awareness and whole person development in students. Under the umbrella of contemplative practices are various forms of mindfulness meditation, such as focused attention and loving kindness meditation, a type of breathing meditation used for wishing good will to one's self and others (Liston, 2016). However, contemplative practices are not only limited to formal meditation practices, but also include various forms of mindful movement such as walking meditation, yoga, and tai chi (Lukoff & Strozzi-Heckler, 2017).

As a theoretical framework for understanding the construct of mindfulness in educational settings, this literature review will utilize Roeser and Peck's (2009) conceptual understanding of mindfulness as a skill that can be practiced and developed and falls under the umbrella of a contemplative education framework, an educational framework intended to promote positive growth and development in childhood by using mindfulness in the classroom. I chose a contemplative education framework to examine the construct of mindfulness because I want to explore this construct in educational settings within a theoretical framework that encompasses a broad variety of secular mindfulness practices, not limited to only meditation. This also includes activities such as mindful movement and mindful eating. For instance, Zajonc (2016) conceptually defines the concept of contemplation as a practice of carving out space for reflection in a way that promotes individual whole well-being. With this understanding of contemplation in mind, contemplative educational practices include a wide variety of instructional strategies that are designed to cultivate mindful awareness in educational settings with both student and educator populations (Roeser & Peck, 2009; Roeser, 2013: Roeser 2016). With this conceptual understanding of mindfulness in place, I will now explore each mechanism of mindfulness individually.

Mindfulness and Attention Regulation

As defined by Bishop and colleagues (2004), achieving a mindful state happens by purposefully orienting attentional awareness to the present moment. Being able to regulate attention and concentrate the mind on what is happening in the moment are valuable cognitive skills for life inside and outside of the classroom. Attentional regulation is defined as the ability to orient attention to external objects and to manage streams of thought (Posner & Dehaene, 1994).

When defining the subcomponents of mindfulness, Bishop and colleagues (2004) argue that mindfulness promotes three specific components of attentional regulation: 1) sustaining attention in the present moment; 2) attention switching between competing stimuli; and 3) inhibition of elaborative processing that could distract attention. Previous research by Garland, Gaylord, and Park (2009) has shown that mindfulness helps to foster metacognitive awareness and control over the attention span. With enough practice in mindfulness meditation one becomes more aware that attention has shifted from one object to another, also one develops a greater ability to return attention back to the original object. This conceptual understanding of mindfulness is supported by research from Jha, Krompinger, and Baime (2007), who examined the relationship between mindfulness and specific processes of attention by administering pre- and post - versions of the Attention Network Test (ANT) to three groups of participants with various experience practicing mindfulness. The ANT is a series of response time tasks that can be administered to children and adults to measure efficiency of alerting attention, orienting, and executive attention. One group was comprised of experienced meditators who were participating in a meditation retreat in which they practiced meditation for as many as 16 hours per day for ten consecutive days. Another group included novice meditators who were enrolled in an eight week

mindfulness-based stress reduction (MBSR) program. Finally, a control group with no meditation experience was used as a baseline for comparison. Results suggest that experienced meditators demonstrated greater conflict monitoring at their pre- assessment compared to the novice group of meditators. This implies that those with more meditation experience are able to monitor their own cognition and determine when their attention has shifted from the present moment to other phenomena. The novice meditator group also showed significant improvements of attention compared to the control group on their post assessment. Overall, the results of their research suggest that mindfulness training has the ability to improve attention on specific conditions of the ANT suggesting that the more an individual practices mindfulness, the easier it becomes to sustain attention in the face of competing stimuli.

Research by Flook and colleagues (2010) provides evidence that mindfulness-based interventions in educational settings can promote executive function of attentional regulation used by students in the classroom. Executive functions are defined by Hofmann, Schmeichel, and Baddeley (2012) as a series of cognitive skills that include working memory operations and behavioral inhibition. Conceptually, mindfulness involves a high degree of cognitive engagement. When an individual intentionally directs their cognition and attention to the present moment without trying to change that moment, this present-moment focus allows for the individual to slow things down enough to see their default cognition in action. Results of research by Flook and colleagues (2010) revealed that a mindfulness-based intervention had the strongest impact for students who scored the lowest on executive function assessments at mindfulness training. This suggests that students who have the most difficulty maintaining their attention during class work would be the students who benefit the most from mindfulness-based interventions.

Together these two studies suggest that practicing mindfulness can develop skills used to maintain attention in the present moment even in the face of competing stimuli. Results of these two studies also suggest that individuals who lack the ability to regulate their attention are the ones who will benefit most from participating in mindfulness-based interventions. This is important in educational contexts because students who are able to maintain their attention on a specific instructional task are more likely to be successful in the classroom compared to students who struggle to do so (Posner & Patione, 2009). Ultimately, learning begins with attention**.**

Mindfulness and Emotional Regulation

Emotions are a part of the broad spectrum of affect that also includes mood and stress response (Gross & Thompson, 2007). Emotions are generated from person-situation interactions, stem from goals, are subjectively interpreted, malleable, and complex bodily responses (Jacobs & Gross, 2014). Emotions experienced in academic settings come in all shapes and sizes. Academic emotions can be experienced by students in terms of their positive or negative valence, as well as whether the emotion activates or deactivates physiological and cognitive arousal (Pekrun & Linnenbrink-Garcia, 2012). Activating emotions, such as enjoyment, interest, or anger typically lead to physiological and cognitive arousal. Deactivating emotions, such as boredom, relief, and feelings of hopelessness are typically associated with decreased physiological and cognitive arousal.

The second component of Bishop and colleagues (2004) definition of mindfulness includes the element of emotional regulation, specifically being open to all emotional experiences from the awareness that emotions are not permanent experiences, but rather are subject to change across time. Mindfulness, according to Teper, Segal, and Inzlicht (2013), leads to a non-judgmental experience of emotions that promotes an openness and sensitivity to

emotional changes which in turn promotes emotional regulation. Noticing subtle changes in emotions through mindfulness makes it easier to regulate emotions. For example, individuals practicing mindfulness may initially experience an unpleasant emotion such as anger. Practicing mindfulness allows individuals to be aware that they are angry in the moment, but in a way that creates distance from the emotion of anger. They can watch the emotion of anger arise and fall with mindful awareness without trying to alter or change the emotional experience, knowing the emotion will pass eventually. This is a similar experience to how a person on a moving train watches objects pass by moment-to-moment, not getting caught up in any particular object**.**

Research on mindfulness indicates that emotional regulation may be an important subcomponent when defining mindfulness (Schonert-Reichl & Lawlor, 2010; Heppner, Spears, Vidrine, & Wetter, 2015). Emotional regulation is defined as the process of how individuals attempt to influence what emotions they experience, and emotions can be regulated in terms of their intensity, duration, and quality (Gross, 2015). Individuals who are better able at differentiating emotional experiences tend to be better at regulating their emotions (Barrret et al, 2001). This is important for studying mindfulness because individuals who practice mindfulness have an opportunity to practice observing and noticing changes between emotional experiences (Teper & Inzlicht, 2013).

There are a number of strategies that can promote regulating emotions, but Gross and Thompson (2007) broadly identified five strategies used for regulating emotions including selecting or avoiding situations, modifying existing situations, deploying attentional resources, changing thoughts, or changing how one responds to a situation. The most common strategies for regulating emotions include suppressing emotions followed by attention deployment, cognitive change, and situation modification (Taxer & Gross, 2018). Mindfulness interventions may be

beneficial in promoting emotional regulation because they can be used as specific strategies for regulating emotions through changing thoughts (Garland, Gaylord, & Park, 2009) and deploying attentional resources (Jha, Krompinger, & Baime, 2007).

Cultivating mindfulness has the potential to teach individuals how to be more aware of the emotions they feel at any given moment and also how to accept those emotions without overreacting. Research by Maloney, Lawlor, Schonert-Reichl, and Whitehead (2016) shows that mindfulness-based interventions have the potential to explicitly teach students a variety of social-emotional skills such as empathy and compassion that are desirable for success in and outside of school. Furthermore, research by Schonert-Reichl and Lawlor (2010) suggests that mindfulness-based interventions can potentially be an effective method for regulating academic emotions and generating positive activating emotions (Pekrun & Linninbrink-Garcia, 2012). This is important in classroom contexts because the emotions students experience in achievement situations can have a profound impact on learning. For example, positive activating emotions such as curiosity and excitement are conducive for learning because students are more likely to be cognitively engaged, whereas negative deactivating emotions such as boredom are not because students are less likely to be engaged cognitively (Pekrun, 2006).

Mindfulness potentially offers a set of skills used to help students improve their ability to regulate their emotions in academic contexts. Garland, Gaylord, and Park (2009) proposed a theoretical model for the role of mindfulness in the processes of positive reappraisal that may shed some light on how mindfulness promotes emotional regulation. Being mindful, according to Garland and colleagues (2009), involves much more than a relaxation technique. Individuals practicing mindfulness can use the skills learned to watch and observe thoughts, emotions, and other mental phenomena arise and dissipate without getting caught up in the emotional

experience. Perhaps their default cognition towards a certain stimulus is initially displeasing or aversive. However, taking a few moments to practice mindfulness allows this individual to reappraise their initial emotional reaction to that stimulus as the emotional experience is non-threatening. Mindful awareness has the potential to promote cognitive reappraisal of the same stimuli as either neutral or pleasant. In other words, emotional regulation through mindfulness is facilitated by this ability to engage in reappraisal of aversive stimuli which creates emotional distance. This is important in classroom contexts because students are likely to encounter a variety of experiences that may initially be emotionally aversive, such as testing, but by practicing mindfulness students have the opportunity to reappraise their initial emotional reaction into something more conducive for learning.

Mindfulness and Schools

Given previous success of mindfulness-based interventions (MBIs) in clinical and non-clinical settings, these interventions are beginning to find their way into a variety of educational settings such as elementary, middle school (Parker & Kupersmidt, 2016) as well as higher education (Hall, 1999) along with various student populations such as college students and student athletes (Goodman,Kashdan, Mallard, & Schumann, 2014), adolescents (Roeser & Pinela, 2014; Broderick & Metz, 2016), and special needs students (Smith & Jelen, 2016). These results suggest that MBIs can be highly malleable to context and population in educational settings.

While many of the tasks traditionally used in MBIs with adolescent and adult populations may be developmentally inappropriate for younger children, research by Lillard (2011) suggests that these interventions can be adapted and used with younger students, including preschool students below the age of five. According to Lillard (2011), through MBIs, preschool students

are taught many of the same skills taught in traditional Montessori schools designed for preschool aged children, including deep concentration, experiencing sensations as present moment phenomena, appreciation of all experiences, simplicity, and promoting a non-judgmental attitude towards experiences. Additionally, both Montessori schools and MBIs promote favorable outcomes centered around attention regulation and positive emotional well-being, suggesting that MBIs have the potential to be used even with preschool children if the program is adapted to meet their developmental needs.

Preliminary evidence from Parker and Kupersmidt (2016) also suggests that MBIs can be tailored to address specific behaviors found in school aged populations including preventing smoking in preadolescents. These authors reviewed research of two mindfulness education programs, *Master Mind* for older elementary students and *Moment* for middle school students. Pilot studies revealed both programs are effective for promoting executive function in younger students. The authors also found a small negative correlation with mindfulness training and intent to smoke cigarettes. While correlation does not imply causation, this is still a positive result worth investigating further. Adolescence may be a specific developmental age range that uniquely benefits from mindfulness-based school programs (Roeser & Pinela, 2014). Programs like *Learn 2 Breathe* taught students a "middle path" on how to cope with the stressors they are likely to encounter during this time of major transition (Broderck & Metz, 2016). According to these authors the typical ways students handle stressors are to either over-engage or disengage in response. Mindfulness training, according to these authors, has the potential to teach adolescents how to tolerate and be less reactive to stressful situations they encounter in schools. This has tremendous implications for learning. Too often it seems as if students are told what not to do,

rather than being told what to do. Mindfulness has the potential to give students an alternative to their default ways in reacting to school stressors.

Not only are mindfulness-based interventions being used in school settings, but the outcomes of these interventions are also useful to the field of educational psychology. Being mindful has been associated with several constructs from educational psychology including *self-regulation* (Galla, Kaiser-Greenland, & Black, 2016; MacKenzie & Baumeister, 2015), *working-memory* (Morrison & Jha, 2015; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Mrazek et al., 2013), *transfer* (Roeser, 2016), *social-emotional learning* (Lawlor, 2016; Maloney, Lawlor, Schonert-Reichl, & Whitehead, 2016) and *resilience* (Siegel, Siegel, & Parker, 2016; Lantieri, Nambiar, Harnett & Kyse, 2016). These connections to educational psychology variables suggest that mindfulness could be beneficial in others classroom-related constructs including test anxiety.

Test Anxiety

Experiencing anxiety is a normal human emotional experience. Being anxious about being tested is also normal. Test anxiety, however, goes above and beyond normal levels of anxiety. Test anxiety happens when students experience highly elevated levels of anxiety, nervousness, or apprehension related to testing situations. Test anxiety is accompanied by physical, behavioral, and affective symptoms (Salend, 2010). Students experience test anxiety for a variety of reasons including fear of failure in high pressured academic situations, poor test taking skills, poor intellectual ability, or striving for perfection (Zeidner, 2014). Experiencing test anxiety is not limited to testing situations, but also occurs when learners prepare for exams and as they reflect on results after taking an exam (Cassasdy, 2004).

In college students, test anxiety is associated with maladaptive cognitive and emotional regulation strategies such as blaming others, engaging in self-blame, rumination, and catastrophizing events (Kamel, 2018). These strategies suggest that college students would benefit by being taught specific strategies for regulating their emotions, especially an intense emotion like test anxiety not only during exams, but also in preparation for exams and how students reflect on exams afterwards.

Test anxiety is a major problem in the classroom at all levels of school with deleterious effects on student performance. Students with high test anxiety do not perform as well academically as their peers with low test anxiety (Chappel et al. 2005). Higher levels of test anxiety prior to examination is negatively correlated with exam scores (Barrows, Dunn, & Lloy, 2013). The type of exam (online v paper) does not appear to impact the experience of test anxiety for college students. However, some degree of control over when to take an exam seems to minimize the perceived threat from the exam (Cassady, Budenz-Anders, Pavlechko, & Mock, 2001).

Test anxiety is thought to be experienced by at least 30% of college students and this may be a conservative estimate (Huberty, 2009). These numbers may in fact be higher for different groups of students, such as students with learning disabilities (Peleg, 2009), ethnic minorities (Carter, Williams, & Silverman, 2008), and female students (Gerwing et al, 2005). Test anxiety also appears to vary by level of experience as a student. Research by Dawood and colleagues (2016) revealed a negative correlation with test anxiety and student's academic level. Students with more scholastic exposure seem to experience less test anxiety than their peers with less scholastic experience. This implies that students at higher academic levels have figured out strategies to either cope with or reduce the experience of test anxiety, or perhaps students with

high test anxiety do not attend college. Additionally, the experience of test anxiety for college students seems to be fairly stable throughout the semester (Cassady, 2001). This suggests that testing is an inevitable part of school, but test anxiety does not have to be an inevitable outcome from testing. As students progress through their academic careers they learn, both directly and indirectly, strategies for being successful in school including how to perform on exams. Rather than wait for students to “get it " as they move forward, all students could perhaps benefit from more explicit instruction on how to cope with anxiety related to exams.

Test anxiety can originate from a number of sources. Some students experience test anxiety because they have a fear of failure, such as a performance-avoidance goal, the concern for failing in front of others (Eum & Rice, 2011). Other students may experience test anxiety from the need to always look good in achievement settings, such as a performance approach goal (Arana & Fulran, 2015). Test anxiety tends to increase when more pressure to succeed is perceived by individual students. Past performance in testing situations may also play a large role in the experience of test anxiety. Students who have experienced failure on exams in the past might dwell on those experiences during their next exam. Students that dwell on such emotional experiences may benefit from learning coping strategies that help them to reappraise testing situations, perhaps initially as threatening, to something that is at least neutral in valence and perhaps even positive.

Test Anxiety in Physics Education

While I have not encountered literature that directly suggests the subject of physics evokes test anxiety more than other college subjects, there is a reasonable case to be made that introductory physics coursework at the college level can be particularly anxiety evoking, especially during testing. Introductory physics courses, like Introductory Physics I and II, are

required in many STEM related majors such as engineering, chemistry, astrophysics, and mathematics. Introductory physics courses serve as gatekeeper courses for moving on further into STEM related programs including pre-med or engineering. Dawood and colleagues (2016) revealed a negative correlation with test anxiety and student's academic level so students in these entry level courses like Introductory Physics are perhaps more prone to experiencing test anxiety. This is problematic for students enrolled in Introductory Physics courses and other STEM related fields given that these majors are associated with a large amount of attrition (Sithole et al, 2017).

Additionally, students may struggle with introductory physics courses because they challenge students to think scientifically, perhaps for the first time in their academic career (Redish, Saul, & Steinberg, 1998). This is not the same thing as thinking about science, but rather thinking systematically and scientifically. Solutions to problems encountered on assignments or exams are not given from up high or found in the back of the textbook, but rather students have to be more open, flexible to new ways of problem solving that are at times challenging. Furthermore, there may be a misalignment with what students and instructors expect during Introductory physics courses. The misalignment comes from the existence of a "hidden curriculum" in which physics instructors expect a constructivist approach to problem solving while students may be using a binary approach (Y/N; Right/Wrong) to problem solving (Redish, Saul, & Steinberg, 1998).

Another challenge found in Introductory Physics courses comes from the reliance on traditional instructional methods for delivering course content such as large lectures instead of instructional approaches that are supported by research and include more student-centered instruction (Henderson & Dancy, 2009). Limiting the instructional techniques to primarily lecture-based compounds the problem of creating the "hidden curriculum" outlined by Reddish

and colleagues (1998). This is meaningful to understanding why physics might be a subject in which test anxiety is higher than other subjects. Having to not only understand the content but how to apply it in new ways could potentially compound the experience of test anxiety for students. Students in these introductory courses may be more prone to experiencing test anxiety from being novice students (Dawood et al., 2016).

Measuring Test Anxiety

Researchers have attempted to measure the construct of test anxiety by using self-report rating scales. Two of the most commonly administered self-report inventories for test anxiety include the Test Anxiety Inventory (Spielberger, 1980) and the Cognitive Test Anxiety Scale (Cassady & Finch, 2014). Each will be examined and critiqued individually.

The Test Anxiety Inventory (TAI) was developed by Spielberger (1980) and measures test anxiety as a two-factor construct. Those two factors include emotionality and worry. Emotionality is intended to cover the physiological/affective aspects of test anxiety while worry covers the cognitive aspects of test anxiety. The TAI is a 20-item inventory that yields a total score of 20 to 80 with higher scores implying higher test anxiety. The TAI is perhaps the most popular instrument for assessing test anxiety.

However, this instrument is also nearly 40 years old. Much has changed with regard to how we think about testing and test anxiety in general. This is why researchers like Cassady and Johnson (2002) crafted an instrument to assess the construct of test anxiety by focusing exclusively on the cognitive aspects of the construct. Cassady and Johnson (2002) created the Cognitive Anxiety Scale, a 27 item assessment based on the assumption that cognitive interference plays a bigger role in the experience of test anxiety than emotionality. Their argument is that physiological sensations of emotions like anxiety alone are not enough to

generate test anxiety. Rather the component of worry in combination with physiological sensations or feelings is what leads to test anxiety. High levels of emotionality do not appear to influence test anxiety when students remain confident in their ability to be successful on exams. In validating the Cognitive Anxiety Scale, the authors used 168 college students, mostly sophomores and juniors. This sample could limit generalizability since test anxiety is more common in younger students. Cassady and Johnson (2002) used the Cognitive Anxiety Scale to predict exam scores and SAT performance compared to the TAI. Results suggest that the Cognitive Anxiety Scale is a reliable measure of test anxiety for sophomore and junior undergraduate students and accurately predicted both SAT scores and exam scores. This instrument also takes into account test anxiety in preparation for exams, not just during exams which is important because test anxiety is not something experienced only during the exam itself. Students with high test anxiety may struggle in their exam preparation related to study time when experiencing high amounts of test anxiety (Cassady, 2004). A potential criticism of this instrument, however, is that Cassady and Johnson (2002) primarily used sophomores and juniors in the development of this instrument. There is a possibility that the experience of test anxiety is different for younger and older college students. Providing students with a set of skills, such as mindfulness training, for coping with their test anxiety could be a potential solution to this academic problem

The Relationship Between Mindfulness and Test Anxiety

Mindfulness training for college students may have potential for addressing the problem of test anxiety. Research by Cho and colleagues (2016) used a one-week self-taught mindfulness intervention to reduce the experience of test anxiety for college students who self-reported as having high test anxiety. A common symptom of test anxiety is the inability to maintain attention

during testing (Salend, 2010). Practicing mindfulness through activities that emphasize focusing attention on the breath or an object can help students stay focused on the present moment by making it easier to recognize when attention has wandered to something distracting or unrelated to the task at hand such as anxious thoughts (Rahl et al., 2016; Lutz, Slagter, Dunne & Davidson, 2008). In addition to the awareness of the presence of intense emotions like anxiety, mindfulness training also teaches individuals how to control their attention and return their attention back to the present (Jha, Krompinger, & Baime, 2007). Instead of sustaining attention on anxious thoughts that make tests more difficult, individuals who practice mindfulness will have a greater ability to return their attention span to what is happening in the present moment, such as the exam at-hand. As described previously, some of the more common symptoms of test anxiety involve mind wandering and ruminating thoughts (Kamel, 2018), both of which can be distracting and potentially detrimental to test performance. Explicitly teaching students how to maintain their own attention in the present moment will allow these students the opportunity to remain focused during exams when their thoughts begin to wander or when they worry about their own performance. Mindfulness is like an anchor in which an individual is to remain grounded in the present even when the mind is trying to move elsewhere.

Participating in a mindfulness-based intervention may also reduce some of the behavioral and psychological symptoms of test anxiety. While this research has not explicitly dealt with mindfulness interventions and test anxiety, there is enough evidence presented to suggest that mindfulness could be effective at treating many of the symptoms of test anxiety such as mind wandering and emotional dysregulation. Research by Rahl and colleagues (2017) found that even brief mindfulness training has a positive effect on reducing mind wandering, or the experience of getting lost in random or distracting thoughts, a common experience for people with test anxiety

(Salend, 2010). Additionally, research by Kemeny and colleagues (2012) shows that participating in a mindfulness-based intervention can result in a reduction of ruminating thoughts, the experience of dwelling on anxiety-evoking thoughts, another common experience for learners experiencing high amounts of test anxiety.

In addition to attention regulation towards the present moment, mindfulness training will also be beneficial for regulating and modifying intense emotions that happen in testing situations. Research by Edenfield and Saaed (2012) has shown that mindfulness training can be used in both clinical and non-clinical populations to treat anxiety. Practicing mindfulness allows individuals to have more emotional distance from anxious feelings as they happen resulting in decreased emotional distress (Kiken & Shook, 2012). This is influenced by the metacognitive awareness that emotions are not permanent experiences, but rather fleeting phenomena that are subject to change with time (Garland, Gaylord, & Park, 2009). Mindfulness training, specifically in the form of open-monitor meditation, gives individuals the opportunity to practice observing emotional experiences (positive or negative) come and go without getting caught up in each emotional experience (Lutz, Slagter, Dunne & Davidson, 2008). Instead of being overwhelmed by intense emotions like anxiety, individuals who practice mindfulness have a set a of skills they can practice when feeling anxious that bring physiological relief, easing the body from “fight or flight” to “rest and digest”, making it easier to see the impermanent nature of emotions like anxiety (Sayers, Creswell, & Taren, 2015). As defined previously, practicing mindfulness allows individuals to be more open and curious towards all emotional experiences, regardless of their valence (Bishop et al., 2004) There is also a possibility that this emotional openness and curiosity evoked from individuals practicing mindfulness will dampen the experience of intense emotions like anxiety. The emotion is still present but the ability to watch the emotion arise and

fall improves the more an individual practices mindfulness. Finally, research by Menezes and Bizarro (2015) used six weeks of focused-attention mindfulness training with non-clinical college students to reduce the experience of trait anxiety and emotional dysregulation, a state of discomforting emotional fluctuation.

Based on previous research in mindfulness-based interventions, I hypothesize that explicitly teaching college students the skills of mindfulness, those students can be empowered to overcome the experience of test anxiety.

Research Questions & Hypotheses

Based on my search of the research literature and knowledge of the field, I have developed the following research question to explore the theoretical relationship between mindfulness and test anxiety:

- What is the predictive relationship between emotional regulation, attentional regulation, mindfulness and test anxiety?

Additionally, I developed the following research question to explore influence that mindfulness training has on test anxiety in college physics students:

- Will an internet-based mindfulness intervention facilitate a reduction in test anxiety more than a control?

To answer the first question, I developed a proposed theoretical model of the relationships between the constructs of mindfulness, emotional regulation, attentional regulation, and test anxiety that is postulated in this research. Mindfulness is conceptualized as a two-factor construct, including awareness of attention and emotional acceptance (Brown et al, 2004). I am postulating here that these two constructs closely map onto the constructs of emotional regulation and attentional regulation, respectivelyPrevious research suggests that participating in

mindfulness-based interventions can have positive effects on the ability to regulate one's emotions (Maloney, Lawlor, Schonert-Reichl, & Whitehead, 2016) and attention towards the present moment (Jha, Krompinger, & Baime 2007). I predict that with a heightened ability to stay grounded in the present moment emotionally and cognitively, individuals who practice mindfulness will have an easier time managing intense emotional experiences such as test anxiety**.** I predict that the mechanisms of attentional regulation and emotional regulation cultivated through mindfulness will reduce the experience of test anxiety by directly targeting those symptoms of test anxiety that produce negative emotions and make it harder to concentrate.

Individuals who practice mindfulness will develop greater awareness of their emotional experiences in the present moment, including an understanding of the impermanent nature of each emotional experience. This in turn will allow the individual to create distance from emotional experiences without getting caught up in intense emotions like test anxiety. Perhaps using mindful awareness, an individual who is anxious about testing can observe those feelings as they are without trying to change them. This use of mindfulness could be used to reappraise those initial feelings of anxiety instead of the feeling of being challenged (Gaylord, Garland, & Park).

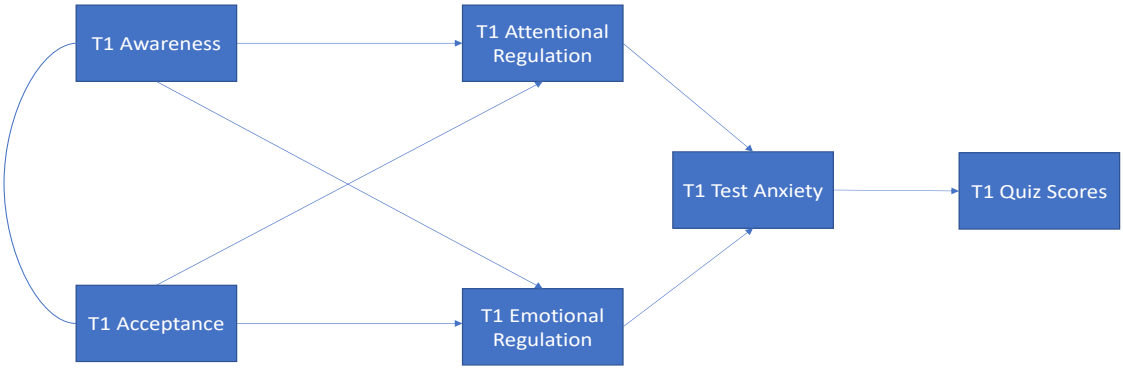
Additionally, individuals who practice mindfulness will develop greater awareness of when their attention has wandered from the present moment and be able to return it back to the present moment. This could be very useful in addressing test anxiety, where thoughts typically wander and ruminate on the stress associated with testing (Salend, 2010). Practicing mindfulness could help individuals realize when their attention has wandered from the test towards anxious

thoughts and then use mindful focused-breathing (Lutz, Slagter, Dunne, & Davidson, 2008) to come back to the present moment of taking the exam.

The hypotheses for this theoretical model are as follows: 1) Participating in mindfulness training will increase participants' ability to regulate their emotions and attention towards the present moment which will in turn; 2) reduce participants' experience of test anxiety and 3) have a positive impact on their exam scores in physics.

Figure 1: Theoretical relationship between measured variables

Figure 1: Hypothesized Theoretical Model



The independent variable for my dissertation research was two levels of treatment (participation in an app-based mindfulness intervention lasting eight weeks or being in the control condition). The dependent variables will be participant scores on the Cognitive Test Anxiety Scale, the Philadelphia Mindfulness Scale, Emotions About Learning instrument, the Self-Regulation Scale, and participant's physics exam grades assessed at the beginning, middle, and end of the intervention. All instruments are listed and described in the Appendices below.

CHAPTER THREE

METHODS

Participants & Context

Participants in this study included 150 undergraduate students from a large public university in the American Midwest. Participants were recruited from a single section of an introductory undergraduate physics II course offered on campus. Of those 160 students, 84 students identified as male, 52 identified as female, and the rest of students did not specify their gender. The average age of participants was 20.51 years. The majority of participants in this study were white/Caucasian with nearly half reporting White or Caucasian as their race/ethnicity. The next largest race/ethnicity represented in this sample was 22 students identifying as Asian. The largest majors from this sample of students were Mechanical Engineering (17), Civil Engineering (13), Chemical Engineering (12), Meteorology (12), and Aerospace engineering (7). Of the 160 participants, 29 students in this study identified as first generation college students. The instructor of this course allows students to receive extra credit for their participation in campus research.

Design

This research was conducted in two ways. First, I administered surveys on test anxiety, emotional regulation, attention regulation, and mindfulness to a large class of introductory physics II students. The purpose of this portion of the research was to explore the theoretical model of mindfulness and test anxiety outlined previously to answer research question one. Those students were given the opportunity to participate in pre- and post- test experimental design to examine the relationship between mindfulness training using an app-based

intervention, emotional regulation, attention regulation, and test anxiety. The independent variables for this research were participating in the mindfulness intervention or not.

Initially, all participants were asked to complete assessments on the aforementioned variables at three different times of the semester (Weeks 3,8,13) for extra credit in their physics class. Participants had the opportunity to earn additional extra credit by participating in an eight week mindfulness-based intervention intended to address test anxiety. The intervention group (N = 64) received a mindfulness training intervention that lasted for eight weeks. Participants were encouraged to practice mindfulness in between sessions using mobile apps for at least five minutes each day using the Insight Timer app. Insight Timer is a free mobile application more practicing mindfulness. Additionally, participants were prompted to use the Insight Timer app by sending Remind notifications. Remind is a free mobile app for sending students notifications. Each week of the intervention was focused around a specific theme to encourage both formal and informal practice (Germer, 2004). Participants who only chose to complete the surveys and not be in intervention served as the natural control group (N = 88) for comparison.

Instruments

Test Anxiety. To assess participants' experience of test anxiety when taking a physics exam, participants were given the Cognitive Test Anxiety Scale, a 27 item, four-point Likert scale instrument (Cassady & Johnson, 2002). The scale is anchored by 1) Not at all typical of me and 4) Very typical of me. Items were modified to reflect the context of a physics test rather than the general test anxiety assessed by the developers of this instrument. An example item from this instrument is "My mind goes blank when I am pressured for an answer on a physics test." The entire assessment can be found in appendix A.

This assessment of cognitive test anxiety measures test anxiety as a unidimensional construct, focusing exclusively on the cognitive aspects of test anxiety. Factor analyses support the unidimensional structure and the instrument has been found to have reliability in the form of internal consistency with a Cronbach's alpha of 0.91. The authors found evidence of concurrent validity by comparing the Cognitive Test Anxiety Scale to the measurement on Reactions to Tests. The two constructs were found to be significantly correlated to one another. (Cassaday & Johnson, 2002). I used Cronbach's Alpha to evaluate the reliability of this scale at each time point, T1 = .948, T2 = .780, T3 = 0.920.

Emotional Regulation. To assess participants' ability to regulate emotions in testing situations, participants were given the Exam Emotion Regulation Questionnaire, a six item, 10-point Likert scale instrument (Levine, Schmidt, Kang, & Tinti, 2012). The items are anchored with 0) not at all and 10) extremely. The instrument asks participants to think about an upcoming exam and reflect on the type of strategies they would use to cope with an exam. Items are broken into three categories of emotional regulation: reappraisal, distraction, and suppression. Example items from the assessment include "I try to see the positive of this experience" (reappraisal), "I take my mind off the exam" (distraction), and "I try to suppress my feelings" (suppression). The entire assessment can be found in Appendix B.

The Exam Emotion Regulation Questionnaire was developed by Levine, Schmidt, Kang, and Tinti (2012) to assess the relationship between strategies individuals use when coping with exams and later memory of those emotions. Internal Consistency using Cronbach's alpha shows that the Exam Emotion Regulation Questionnaire has questionable reliability with scores of 0.86 for reappraisal items, 0.36 for distraction items, and 0.70 for suppression items. Despite, subpar reliability scores, I used this instrument to measure emotional regulation because this instrument

places the construct in the realm of testing and examines specific strategies of emotional regulation relevant to both mindfulness and test anxiety – reappraisal, distraction, and suppression. I used Cronbach's Alpha to evaluate the reliability of this scale at each time point, T1 = 0.505, T2 = 0.571, T3 = 0.576.

Attentional Regulation. To assess participants' ability to regulate their attention when taking a physics exam, I used the Self-Regulation Scale, a ten item, four-point Likert scale assessment of self-regulation (Diehl, Semegon, & Schwarzer, 2006). Items on this instrument are anchored by "Not at all true" (1) and "Completely true". Items were modified to fit the context of a physics exam. An example item from this assessment is "I can control my thoughts from distracting me from a physics exam" The entire assessment can be found in Appendix C. The Self-Regulation Scale was found to be a reliable instrument by Diehl and colleagues (2006) with Cronbach's alpha scores ranging from .76 to .84 across three waves of assessment. I used Cronbach's Alpha to evaluate the reliability of this scale at each time point, T1 = 0.852, T2 = 0.400, T3 = 0.861

Mindfulness. To measure the construct of mindfulness I used the Philadelphia Mindfulness Scale, a 20-item, five-point Likert scale instrument (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). Items on this instrument are anchored by "never" and "very often" with "sometimes" (3) in the center. The Philadelphia Mindfulness Scale is broken into two distinct components: items assessing awareness and acceptance. An example item from the awareness section is "I am aware of what thoughts are passing through my mind." An example item from the acceptance section is "I wish I could control my emotions more easily." The entire assessment can be found in Appendix D.

There are numerous instruments for measuring mindfulness including but not limited to the Mindful Attention Awareness Scale (Brown & Ryan, 2003) and the Toronto Mindfulness Scale (Lau et al. 2006). I chose to use the PHLMS because this instrument assesses the construct of mindfulness as a two factor construct similar to the way I am conceptualizing mindfulness for this study; present moment awareness that results in regulation of attention and emotion. Research by Cardaciotto and colleagues (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008) found the PHLMS to have internal reliability with each factor, the Awareness subscale, Cronbach's alpha = .81 and the Acceptance subscale, Cronbach's alpha = .85. The authors also found moderate correlations with the PHLMS and mindful awareness/attention I used Cronbach's Alpha to evaluate the reliability of this scale at each time point T1 = .812, T2 = 0.791, T3 = 0.830.

Physics Quiz Scores. I used quiz scores for the most recent physics examinations at T1, T2, and T3. The purpose of collecting this data was to explore the potential impact that reducing test anxiety has on academic performance. The quiz taken at T1 included twelve multiple choice items (A-E) on the subject of electric fields and dipoles. The entire assessment can be found in Appendix J.

At T2, participants completed a group discussion problem on the topic of cyclotron motion, the mass spectrometer, instead of completing a multiple-choice quiz. They completed the group discussion activity because the course transitioned from in-person to online during the semester. Students were evaluated on this discussion as a group. The group discussion problem included a single, longer physics problem that the students were asked to solve in groups of two to three students under the guidance of a course Teaching Assistant. According to the course instructor, the discussion problems given for this assignment were harder than normal homework

problems and emphasize more problem solving strategies. The entire assessment can be found in Appendix K.

At T3, participants completed an in-class assessment over the topic of Faraday's Law and inductance. The assessment contained eight multiple choice items and was completed during an online zoom class session because the class transitioned from in-class to online due to the COVID-19 outbreak. The entire assessment can be found in Appendix L.

Pre Data Manipulation Check. During Time 1 data collection I provided items to participants asking if they would like to participate in the intervention portion of this study, if they have experience practicing mindfulness, and to evaluate their own motivation to do something about test anxiety. These items were used for enrolling participants into the intervention portion of this study. The instrument can be found in appendix E.

Intervention Manipulation Check. In order to assess the level of participation in the mindfulness intervention, I asked participants once per week through the Remind app how often they practiced mindfulness out of the last seven days as measured by the Insight Timer App. This allowed me to estimate how frequently participants actually engaged in the intervention. Instruments can be found in appendix F.

Insight Timer app. I asked participants to download the Insight Timer mobile phone application to facilitate mindfulness practice between pre and post data collection sessions (Mani, Kavanagh, Hides, & Stoyanov, 2015). Insight Timer is a free mobile app that allows users to practice mindfulness daily. Insight Timer users can open the app each day and create a timed meditation where the app will signal the beginning and end of the meditation. Users can customize the length of their meditation, add ambient sounds, and modify the sound used to signal the beginning and end of the meditation. I chose this particular app because it is simple to

use and will provide all participants in the mindfulness intervention with a similar experience of practice. A picture of the Insight Timer app is shown in Appendix H.

Remind app. I used the Remind mobile app to send notifications to participants to practice mindfulness using the Insight Timer app. In addition to sending reminders, I will also use this app to send daily tips on how to practice mindfulness in everyday life and also provide readings on the subject of mindfulness each week. Remind is a free mobile phone app that is commonly used in educational settings and allows for instructors to send notifications, assignments, etc. to students who are also signed up to use the application. A picture of the app is shown in Appendix I.

Daily Tips. As part of the mindfulness intervention, participants were also sent daily tips through the Remind notification app on how to incorporate elements of mindfulness into their daily lives. Each daily tip was written by mindfulness scholar Thich Nhat Hanh (2016) and were written to be short, digestible tips about learning mindfulness. The entire collection of Daily Tips can be found in Appendix M.

Procedures

Participants were recruited from an undergraduate introductory physics course at a large university in the Southwest. Students from this class were given a verbal description of the study. They were informed that there are two opportunities to earn extra course credit from participating. The first opportunity for extra credit involved completing surveys at three different time points of the semester. The second opportunity was extended to those students who wished to earn additional extra credit by participating in an eight-week mindfulness intervention intended to address test anxiety.

Those who chose to participate in the intervention portion of this research were provided with an online Qualtrics link to sign up for participation. They were asked to enroll in a single in-person session for learning about mindfulness and getting participants signed up for the mobile phone apps (Remind and Insight Timer). Participation in this study was voluntary for those who wanted to obtain extra credit in their coursework.

Pre data collection from all participants took place in their physics class by sending out a Qualtrics link at the beginning of class with each of the survey instruments described above. Participants were given one week to complete. This first round of data collection also included an item about the participants' motivation to address test anxiety, an item about participant's experience practicing mindfulness, and another item about participant's motivation to participate in the intervention.

After pre data has been collected, I used this data to identify participants who wanted to participate in the intervention. Participating in the intervention portion of this research began with a group in-person meeting. The purpose of this meeting was to teach participants about mindfulness, including a PowerPoint with definitions, rationale for practicing, and how to establish a daily mindfulness practice. This presentation included a focus on two specific types of meditation for participants to engage in when using the app - focused attention and open-monitoring (Lutz, Slagter, Dunne, & Davidson, 2008). The purpose of teaching these two types of meditation is to facilitate the development of attentional and emotional regulation. I also read out loud a short children's book on mindfulness titled "King Calm" (Sweet & Miles, 2016) to illustrate the different ways to practice mindfulness in their everyday lives.

In addition to mindfulness instruction, participants also were shown how to download two mobile apps for practicing mindfulness - Insight Timer and Remind. Intervention

participants were informed that they would receive daily reminders, articles and tips for practicing mindfulness from the Remind app. Participants will be given prompts Monday through Friday. On Friday, participants will be asked to self-report their level of intervention participation from the previous week (See Appendix F). Below is a sample outline of what prompts participants received each day in a typical week:

- Monday - Send out a short informational video (5 minutes) about the theme for that week. Send out a reminder to use the Insight Timer app (what technique to focus on) plus a short tip from Thich Nhat Hanh (2016).
- Tuesday - Send out a reminder to use the Insight Timer app (what technique to focus on) plus a short tip from Thich Nhat Hanh (2016).
- Wednesday - Send out a reminder to use the Insight Timer app (what technique to focus on) plus a short tip from Thich Nhat Hanh (2016).
- Thursday - Send out a reminder to use the Insight Timer app (what technique to focus on) plus a short tip from Thich Nhat Hanh (2016).
- Friday - Send out a reminder to use the Insight Timer app (what technique to focus on) plus a short tip from Thich Nhat Hanh (2016). Also send out a survey where participants self-report how often they practiced mindfulness out of seven days.

The eight-week online mindfulness-based intervention was designed similarly to an online intervention used by Morledge and colleagues (2013) who used an eight-week online mindfulness based intervention to target participant stress. Their intervention included themes, articles, and daily tips each week to help participants develop their own mindfulness practice and how they can use the skills to address test anxiety. The intervention I used for this research

targeted a specific psychological outcome in test anxiety (Lippman, Heinzle, & Narciss (2018) and included opportunities to practice mindfulness both formally and informally throughout the intervention (Germer, 2004). Additionally, each week of the intervention was intended to promote the development of both attention and emotional regulation by using a combination of focused attention and open-monitoring meditation as the foundational skills used throughout the intervention.

Additionally, each week of the intervention was designed around a theme for developing the skills of mindfulness. Participants were given a brief video through Remind at the beginning of each week to outline the theme for that week and how to maintain a daily practice. Each video was used for describing the theme for that week and explaining why that theme is important for developing the skills of mindfulness, and more specifically how those skills can be used for treating test anxiety. Before leaving the in-person session, participants were shown how to use the Insight Timer app by practicing mindfulness for approximately five minutes. The in-person session lasted for approximately one hour.

Remind notifications were sent out to participants in the treatment condition five times per week for eight weeks between pre and post data collection. The following notification were sent to participants: “Hello. This is a friendly reminder to take a few minutes out of your day to practice mindfulness using the Insight Timer app. We recommend using the app in a quiet environment, perhaps to start or end your day. Kind regards, John Chancey and the OU MOVE Research Lab.”

At the beginning of each week, participants were sent a short video (five minutes or less in length via Remind) in which they were given a theme for what to focus their mindfulness training on for that week and how to apply that theme throughout the week. Each video was

presented to encourage participants to practice mindfulness daily but especially when strong emotions arise such as anxiety or stress from testing. Each theme was intended to teach participants both formal and informal practices of mindfulness that can be used in their everyday lives (Germer, 2004). Each theme is described in detail below.

Table 1: Eight Week Online Mindfulness Intervention

Session	**Theme**	**Objective**	**Reading**	**Daily Tips**
Pre-data Collection	What is mindfulness?	Meeting in-person for pre data collection. First meeting included a short PowerPoint presentation describing what mindfulness is and why it is important to practice, and a reading called King Calm. Participants were shown how to download and use Insight Timer and Remind apps before leaving.	What is mindfulness? https://greatergood.berkeley.edu/topic/mindfulness/definition#what-is-mindfulness	Reading King Calm by Sweet & Miles (2016)

Week 1	Focused Attention Meditation	First online week of mindfulness training. Participants were taught the basics of mindfulness meditation beginning with focused attention meditation, where participants were encouraged to begin their practice by sitting in a quiet space with their eyes open or closed and watch their breath as it comes in and goes out. The goal of this particular exercise is to help develop the skills of attentional regulation by having participants practice focusing their attention on a single stimulus (the breath).	A Meditation to Focus Attention https://www.mindful.org/a-meditation-to-focus-attention/	Thich Nhat Hanh reflections on Attention from "How to Sit" Body, Mind, and Breath Meditation Enjoy Your Breathing The Joy of Meditation Seeing Clearly

Week 2	Open-monitoring meditation	Participants were continuing the development of their own practice of mindfulness meditation, but this week the focus was on open-monitoring meditation, where participants were asked to observe all phenomena that arise during their meditation without trying to change or alter any particular phenomena. The goal of this activity is to help develop skills of emotional regulation by engaging in the practice of watching phenomena like thoughts and emotions arise and disappear.	The Best Meditation Technique for Boosting Creativity https://www.yogabasics.com/connect/yoga-blog/best-meditation-for-creativity/	Thich Nhat Hanh reflections on openness and curiosity from "How to Sit": What to do Letting Go Recognizing the Body A River of Feelings Weathering the Storm of Strong Emotions

Week 3	Mindful Eating	Participants were taught how to bring mindful awareness to when they eat a meal with the goal of enjoying each meal when attention is placed on the food itself, and not on other distractions such as thoughts, Netflix, etc. Eating is something people have to do every day but it is very easy to eat without being aware of what we are eating. Participants were taught that they can use mindful eating to help relieve test anxiety. For example, a participant could engage in mindful eating before they leave the house on the day of an exam.	8 Steps to Mindful Eating https://www.health.harvard.edu/staying-healthy/8-steps-to-mindful-eating -	Thich Nhat Hanh's "How to Eat". Mindful Eating Eating Without Thinking One Mindful Breath A Silent Meal The Right Amount

Week 4	Mindful Walking	Participants were taught how to bring mindful awareness to when they walk with the goal of being present with each step when attention is placed on the step itself, and no other distractions. Walking is something people have to do every day but it is very easy to walk without being aware of what we are walking. Participants were taught that they can use mindful walking to help relieve test anxiety. For example, a participant could engage in mindful walking as they walk from their car to class on exam day.	Walking Meditation https://ggia.berkeley.edu/practice/walking_meditation	Thich Nhat Hanh's "How to Walk". Creating a Habit of Mindful Walking Listen to Your Lungs Intention Whole Body, Whole Mind Slow Walking

Week 5	Mindful Sitting	Participants were taught how to bring mindful awareness to when they sit with the goal of just sitting for the sake of sitting. Sitting is something we have to do every day in school and in life, but it can be hard to find the time to sit when our days become busy with obligations and stress. Participants were taught that they can use mindful sitting to help relieve test anxiety. For example, a participant could engage in mindful sitting before and during exams to help remain grounded in the present.	Don't Just Do Something - Sit there? https://www.mindful.org/dont-just-do-something-sit-there/	Thich Nhat Hanh's "How to Sit". Enjoy Your Breathing Following Your Breath Why sit? The Non-Practice Practice Arriving Home

Week 6	Mindful Compassion	Participants were taught how to use mindfulness to foster greater compassion for themselves and other beings. They were taught loving-kindness meditation, also known as metta. Participants were taught that they can use mindful compassion to help relieve test anxiety. For example, a participant could engage in the metta practice to combat anxious thoughts before, during, and after taking an exam.	Greater Happiness in 5 Minutes https://greatergood.berkeley.edu/article/item/better_than_sex_and_appropriate_for_kids	Thich Nhat Hanh's "How to Love". The Practice of Metta Loving Kindness Immeasurable Minds Attention Digging Deep

Week 7	Mindful Relaxing	Participants were taught how to use mindfulness to relax their body and mind. Relaxing is something that can be very difficult to achieve when we have a lot of anxiety or stress from life, work, school, etc. Participants were taught that they can use mindful relaxation to help relieve test anxiety. For example, a participant could use techniques taught in this intervention to relax more in between exams.	Six Relaxation Techniques to Reduce Stress https://www.health.harvard.edu/mind-and-mood/six-relaxation-techniques-to-reduce-stress	Thich Nhat Hanh's "How to Relax". Relax Awareness of Breathing Resting Poem Calm Waters Healing Energy

Week 8	Mindful Movement	Participants were taught how to bring mindful awareness to when they move their body. Movement is something we have to do every day, but it can be hard to find the time when our days become busy with obligations and stress. Participants weresent a short video recorded by the author showing them how to practice a series of four mindful movements that can be done at home or away. Participants were taught that they can use mindful movements to help relieve test anxiety. For example, a participant could practice the four mindful movements before leaving the house on an exam day or in their seat as the prepare for their exam.	What is Yoga? https://www.takingcharge.csh.umn.edu/yoga	Five Mindful Movements that can be practiced with minimal amount of time and/space. Sitting/StandingTadasana(Touchdown) Sitting/StandingSidebends Sitting/Standing Backbend Dancer's pose Participants will be encouraged to practice these movements at least once per day.
Post-Data Collection	How to continue practicing?	This was the last week of the intervention where participants were sent a short video presentation on how to keep practicing mindfulness.	9 Ways to Practice Mindfulness That Don't Involve Sitting Still https://mindfulminutes.com/9-ways-to-practice-mindfulness-that-dont-involve-sitting-still/	

		Participants were commended for their participation.		

In addition to Remind notifications, participants in the treatment condition were sent daily tips through the Remind app on how to maintain and continue their practice of mindfulness throughout the week both formally and informally. Those tips came from a series of short readings by prominent mindfulness instructor Thich Nhat Hanh (2016). Each tip was short and easy to read so that participants can easily use the tips to improve their practice of mindfulness.

All participants of this study were given a Qualtrics link via Canvas to complete data collection materials at week four, the midway point of the intervention, and again at week eight, when the intervention had concluded. This happened at weeks seven and 11 of the semester, respectively. Participants were also asked to complete all materials including the demographic survey (see Appendix G).

Participants in the control condition were those who chose not to participate in the intervention and only complete the surveys. They did not receive any form of mindfulness instruction initially. Nor were participants from the control condition asked to download or use any mobile phone apps in between pre and post data collection. The control group completed all pre and post measures as a baseline for comparison with the treatment condition. I wanted to be able to isolate the effects of participating in a mindfulness intervention on test anxiety.

Participants in the control condition were given an opportunity to receive the same mindfulness instruction as the treatment group after the study has completed.

Analysis

The aim of this research was 1) to explore the theoretical relationship between participating in mindfulness training, emotional regulation, attentional regulation, and test anxiety in college students and 2) to explore the effects of participating in an 8-week mindfulness intervention on test anxiety. Data was collected through the quantitative instruments described above.

Using AMOS, I also used the data collected to test a proposed model depicted in Figure 1 (Schumacker & Lomax, 2004). The measured variables of mindfulness divided into two factors of acceptance and awareness, emotional regulation, attention regulation, physics exam grades, and demographic variables were used to explore the effects of mindfulness on test anxiety. The purpose of this statistical procedure was to explore and understand the influence of the predictor variables of mindfulness, emotional regulation, attentional regulation, on the outcomes of test anxiety and student's physics exam grades. The influence of the predictor variables was assessed for direct effects, indirect effects, and total effects.

Using SPSS, the results of each pre and post instrument were analyzed and compared using repeated measures ANOVA to explore the impact of the 8-week mindfulness intervention. The purpose of this statistical procedure was to compare participants' mean scores from pre data collection to post data collection for significant changes in test anxiety scores.

Expected Outcomes

1) **What is the relationship between emotional and attentional regulation, mindfulness and test anxiety?**

This first question was intended to explore the operational definition of mindfulness in relation to academic outcomes. I am conceptually defining mindfulness as a unique cognitive skill set that is facilitated by emotional and attentional regulation. Previous research suggests that practicing the skills of mindfulness results in 1) a greater ability to regulate emotional states (Maloney, Lawlor, Schonert-Reichl, & Whitehead, 2016) and 2) a greater ability to maintain attention on the present (Jha, Krompinger, & Baime, 2007). I predict that attentional and emotional regulation are the two mechanisms fostered from practicing mindfulness training and increases in each mechanism will result in a reduction in test anxiety.

2) Will an internet-based mindfulness intervention facilitate a reduction in test anxiety more than a control?

While research using mindfulness-based interventions have not been used for addressing the problem of test anxiety, there is substantial evidence that participating in mindfulness-based interventions could result in a decrease in the experience of test anxiety. Mindfulness training has been used successfully in treating other forms of anxiety such as social anxiety (Goldin and colleagues, 2016) and post-traumatic stress disorder (Lukoff & Strozzi-Heckler, 2017). While the experience of anxiety is by no means universal there is also evidence that participating in mindfulness-based interventions is associated with reductions in some of the more common symptoms of test anxiety including mind wandering (Rahl et al., 2017) and ruminating thoughts (Kemeny, Foltz, Cavanagh, Cullen, Giese-Davis, Jennings, & Ekman, 2012).Mindfulness training will also provide participants with a set of techniques that will make it easier to calm the body down from “fight-or-flight” to “rest-and-digest”. Based on previous research findings and my theoretical conceptualization of mindfulness, I predict that the mindfulness intervention used

in this research will reduce participants' test anxiety as measured by the Cognitive Test Anxiety Scale.

CHAPTER FOUR

RESULTS

This research attempted to answer two questions: 1) What is the relationship between emotional and attentional regulation, mindfulness and test anxiety? 2) Will an internet-based mindfulness intervention facilitate a reduction in test anxiety more than a control? Results will be presented by first looking at descriptive statistics followed by addressing question one and results of path analysis. Afterwards, I will address the results of question two through the results of repeated measure analyses.

Path Analysis

To address question one, *what is the predictive relationship between emotional regulation, attentional regulation, mindfulness and test anxiety,* I used AMOS 17.0 to create a series of path analyses in this study. The purpose of this procedure was to test my proposed path model using data at Time 1 using 150 participants. This statistical procedure was conducted using Time 1 data to explore the relationship between each of the measured variables. Model fit for the path analysis was judged using the $\chi 2$, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI) and the Root Mean Square Error of Approximation (RMSEA). According to Schumacker and Lomax (2004), good fitting models exhibit a $\chi 2$ less than 5.0, CFI values >.95, TLI values >.95, and RMSEA values at between .08 and .05 or less.

Table 2 contains the fit statistics for the initial hypothesized model (Model 1) developed for this study. Figure 2 contains the standardized path coefficients for Model 1. Based on the results of the path analysis, the initial model does not appear to be a good fit as indicated by $\chi 2$, CFI, TLI, and RMSEA values that fell outside of acceptable ranges. The direct effects of Awareness on Self-Regulation were statistically significant and positive. The direct effects of

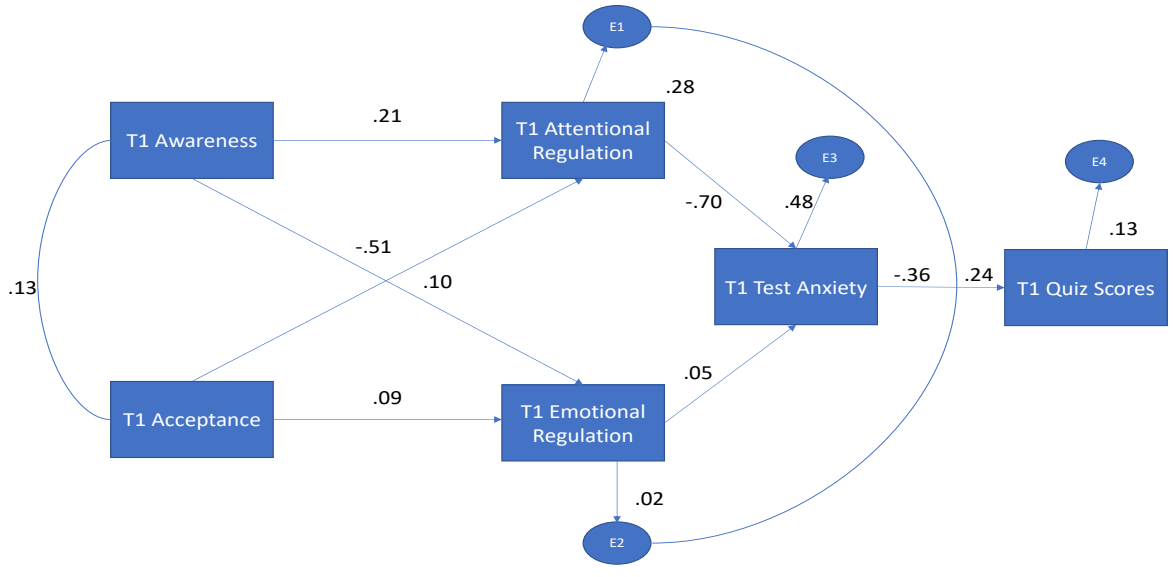
Acceptance on Self-Regulation were also significant; however, the effects were negative. The direct effect of Self-Regulation on Test Anxiety was also significant and negative. Finally, the direct effect of Test anxiety on grades was significant and negative. The direct effects of Acceptance to Emotional Regulation, Awareness to Emotional Regulation, and Emotional Regulation to Test anxiety were each positive but were not significant. The correlation between the two facets of mindfulness, Acceptance and Awareness, were positively correlated (.133) albeit weakly.

Table 2: Results of Path Analysis

Model #	Description of model re-specification	χ^2 test	TLI	CFI	RMSEA / pclose	AIC
1	Initial model	χ^2 (6) = 20.207, p<.001	.715	.919	.124, pclose=.01926	62.207
2	Addition of direct effects from mindfulness facets to anxiety	χ^2 (4) =12.255, p=.016	.751	.952	.117, pclose=.0589	58.255
3	Removed non-sig paths	χ^2 (8) =16.411, p=.037	.873	.952	.083. pclose=.151	54.411

4	Removed emotion reg and error covariance. Added direct effects from mindfulness facets to test grade	χ^2 (2) =3.233, p=.199	.944	.993	.064, pclose=.3157	39.233
5	Final model after deleting non-sig direct effect from awareness to grades	χ^2 (3) =3.892, p=.2734	.973	.995	.044, pclose=.4283	37.892

Figure 2: Path Model for Theoretical Relationship between Measured Variables Model 1



I respecified the hypothesized model by adding direct effects from the two subcomponents of the measured mindfulness variable (awareness and acceptance) to test anxiety. From a theoretical standpoint, these additional paths can be justified because I am predicting that individuals who show greater awareness of when their attention has wandered and acceptance of emotional experiences at T1 are more likely to experience less test anxiety compared to those who score lower on these two variables.

Model 2 fit the data better than Model 1, but all of the fit indices were outside of the acceptable range except for CFI (.952). Additionally, the Aikaike Information Criterion (AIC) value was smaller in Model 2 (58.255) than in Model 1 (62.207). Similar to Model 1, the direct effects of Awareness on Self-Regulation and Awareness to Test Anxiety were statistically significant and positive. The Direct effects of Acceptance to T1 Self-Regulation, Self-Regulation, and Test Anxiety were each significant and negative. The direct effects of Acceptance to Emotional Regulation, Awareness to Emotional Regulation, and Acceptance to Test Anxiety were each positive, however not significant.

Based on the results from Model 2, I further respecified the path model by removing all non-significant paths. The fit of this model was better than Model 2 for each index, but all of the fit indices remained outside of the acceptable range except for CFI (.952). There is also evidence of better model fit compared to model 2 because AIC score was lower in Model 3 (54.11) than Model 2. The direct effects of Awareness to Self-Regulation and Awareness to Test Anxiety were each positive and significant. The direct effects of Acceptance to Self-Regulation, Self-Regulation to Test Anxiety, and Test Anxiety to Grades were each significant and negative.

In model 4 I respecified the path model by removing emotional regulation and the error covariance associated with this variable. This was done because the emotional regulation

variable appears to lack predictive power for test anxiety or grades. Additionally, I added direct effects from the two subcomponents mindfulness (awareness and acceptance) to Test Grades. The fit for Model 4 was an overall improvement over Model 3 based on the accepted fit statistics including AIC scores dropped from 54.411 in Model 3 to 39.233 in Model 4. The direct effects of Awareness to Self-Regulation, Awareness to Test Anxiety, Acceptance to Grades were each positive and significant. The direct effects of Acceptance to Self-Regulation, Self-Regulation to Test Anxiety, and Test Anxiety to Grades were each significant and negative. Finally, the direct effect of Awareness to Grades was positive, but non-significant.

Model 5 (see figure 5) was the final model explored in this study. Model 5 was created after deleting non-significant direct effects from awareness to exam grades. Based on an examination of the relative fit of all the models, it appears that Model 5 represented the best overall fit for the data collected in this study. See Figure 8 for the path coefficients for model 5. The direct effects of Awareness to T1 Self-Regulation, Awareness to Test Anxiety, and Acceptance to Grades were each positive and significant. The direct effects of Acceptance to Self-Regulation, Self-Regulation to Test Anxiety, and Test Anxiety to Grades were each negative and significant.

Since Model 5 was the best fitting model I reported on the indirect effects from that model. Not all of the indirect effects in the model were statistically significant ($p > .05$). Table 9 contains the unstandardized and standardized indirect effects. Acceptance was a significant positive indirect predictor of Test Anxiety while Awareness was a significant negative indirect predictor of T1Test Anxiety. Additionally, attentional regulation was a significant positive indirect effect to Quiz grades. Furthermore, part of the impact of Acceptance and Awareness on

Quiz grade flowed through the variable of attentional regulation, however, these indirect effects were not significant.

Figure 3: Path Model for Theoretical Relationship between Measured Variables Model 5

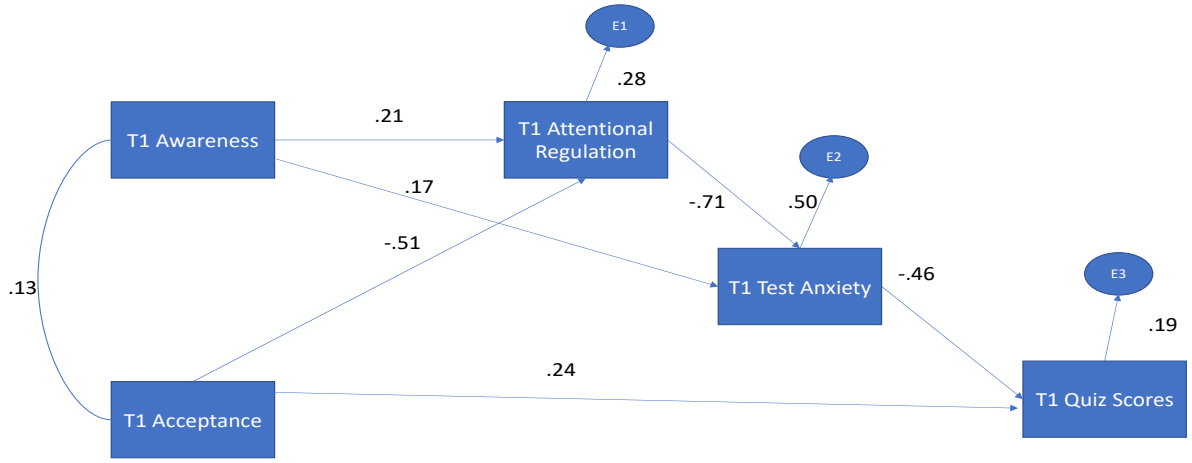


Table 3: Indirect Effects of Model 5

Indirect Effects	Standardized	Unstandardized
T1 Acceptance ⇒ T1 Test Anxiety	.811	.364
T1 Awareness ⇒ T1 Test Anxiety	-.461	-.149
T1 Acceptance ⇒ T1 Grades	-.471	-.166
T1 Awareness ⇒ T1 Grades	-.034	-.009
T1 Self-Regulation ⇒ T1 Grades	1.321	.323

Intervention Findings

Table 4 shows the means, standard deviations, skewness, and kurtosis for treatment and control on the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time One. All skewness

and kurtosis values were less than or equal to an absolute value of three, indicating that the assumption normality can be used for the remainder of my analyses (Lomax & Hahs-Vaughn, 2012). Table 5 contains the correlations between each of the measured variables at Time 1. Additionally, no outliers were found in the data. All data screening techniques, descriptive statistics, and advanced statistical analysis were conducted using the SPSS 24 software.

Table 4: Descriptive Statistics for T1

Descriptive Statistics for scores on the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time One.

	Treatment (N = 60)				Control (N = 93)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
Test Anxiety	75.0333	16.60301	-.288	-.832	69.9333	17.03387	.031	-.826
Emotional Regulation (Total)	36.1667	7.70025	.489	-.133	35.8495	6.75172	.243	.174
Philadelphia Mindfulness Awareness	37.2931	5.68781	-.172	-.213	35.4382	5.21134	-.200	.649
Philadelphia Mindfulness Acceptance	35.5932	8.67441	-.245	-.647	33.9444	6.79451	.173	-.509

Attention Regulation	27.5333	5.29940	.094	-.370	28.4667	5.12278	-.248	-.311
Quiz Grades	82.6667	19.12197	-.757	-.608	77.0115	2.44214	-.485	-.991

Table 5: Correlation Data from T1 Data

	Test Anxiety	Grades	Aware	Accept	Emo Reg	Atten Reg
Test Anxiety	1	-.361**	.063	.430**	-.077	-.684**
Grades	-.361**	1	.072	.060	-.020	.135
Awareness	.063	.072	1	.131	.105	.152
Acceptance	.430**	.060	.131	1	.105.	-.482**
Emotional Reg	-.077	-.020	.105	.202	1	.159
Attentional Reg	-.684**	.135	.152	-.482**	.159	1

**= p >.001 (2-tailed)

Differences between the two conditions at Time 1 were investigated by implementing an independent sample t-test on each of the pretest measures including the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time One. All Pretest scores did not differ significantly between the two conditions, except for scores on the Awareness scale of the Philadelphia Mindfulness instrument where the treatment group scored significantly higher than the control (see Table 6). Overall, these results suggest that it can be assumed that there were no significant differences between conditions that may skew results except for the Awareness variable. That is, equality could be assumed between the treatment and comparison condition with regard to the pretest instruments.

Table 6: Time 1 Group Differences

Independent Sample *t*-score and Descriptive Statistics for the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time One.

Variable	Treatment Mean	Treatment SD	Control Mean	Control SD	t	P
Test Anxiety	75.0333	16.60301	69.9333	17.03387	-1.815	.072
Emotional Regulation (Total)	36.1667	7.70025	35.8495	6.75172	-.268	.789
Philadelphia Mindfulness Awareness	37.2931	5.68781	35.4382	5.21134	-2.034	.044
Philadelphia Mindfulness Acceptance	35.5932	8.67441	33.9444	6.79451	-1.296	.197
Attention Regulation	27.5333	5.29940	28.4667	5.12278	1.067	.288
Quiz Grades	82.6667	19.12197	77.0115	2.44214	-1.577	.117

Table 7 shows descriptive statistics including means, standard deviations, skewness, and kurtosis for treatment and control on the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores (Discussion based) at Time Two. All skewness and kurtosis values were less than or equal to an absolute value of three, except for quiz scores at Time 2 (Lomax & Hahs-Vaughn, 2012).

Table 7: Descriptive Statistics for scores on the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time Two.

	Treatment (N = 60)				Control (N = 93)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
Test Anxiety	71.22	15.69	.037	.937	71.80	13.72	.083	-.613
Emotional Regulation (Total)	36.93	7.86	.243	.169	36.89	7.86	-.057	-.192
Philadelphia Mindfulness Awareness	37.54	5.31	.212	-.980	35.23	5.78	-.196	.420
Philadelphia Mindfulness Acceptance	34.93	6.92	.069	-.808	34.34	6.45	.096	-.274
Attention Regulation	28.13	5.29	-.211	-.565	27.09	5.23	.305	.053
Quiz Grades	4.57	1.11	-4.22	18.51	3.99	1.82	-1.67	1.00

Table 8 shows the differences between two conditions at Time 2. This was accomplished by using an independent sample t-test on each of the T2 measures including the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia

Mindfulness Scale, and T2 Quiz Scores. T2 scores did not differ significantly between the two conditions, except for scores on the Awareness scale of the Philadelphia Mindfulness instrument where the treatment group scored significantly higher than the control (see Table 9) and Quiz grades at T2, where the treatment condition scored significantly higher.

Table 9: Time 2 Group Differences

Independent Sample *t*-score and Descriptive Statistics for the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time Two.

Variable	Treatment Mean	Treatment SD	Control Mean	Control SD	t	P
Test Anxiety	71.22	15.69	71.80	13.72	.232	.817
Emotional Regulation (Total)	36.93	7.86	36.89	7.86	-.30	.976
Philadelphia Mindfulness Awareness	37.54	5.31	35.23	5.78	-2.432	.016
Philadelphia Mindfulness Acceptance	34.93	6.92	34.34	6.45	-.524	.601
Attention Regulation	28.13	5.29	27.09	5.23	-1.228	.222
Quiz Grades	4.57	1.11	3.99	1.82	-2.170	.032

Table 10 shows descriptive statistics including means, standard deviations, skewness, and kurtosis for treatment and control on the Cognitive Test Anxiety Scale, Exam Emotion

Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time Three. All skewness and kurtosis values were less than or equal to an absolute value of three, except for quiz scores at Time 3 (Lomax & Hahs-Vaughn, 2012).

Table 10: Descriptive Statistics for T3

Descriptive Statistics for scores on the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time Three.

	Treatment (N = 60)				Control (N = 93)			
	Mean	SD	Skewness	Kurtosis	Mean	SD	Skewness	Kurtosis
Test Anxiety	68.65	14.55	0.253	-0.759	70.34	14.80	-0.44	-0.729
Emotional Regulation (Total)	37.65	7.72	-.004	-0.811	37.65	6.79	-0.154	0.070
Philadelphia Mindfulness Awareness	36.87	6.07	0.159	-0.534	35.24	5.74	-0.116	-0.394
Philadelphia Mindfulness Acceptance	35.32	7.93	0.024	-0.994	33.50	6.55	0.313	0.159
Attention Regulation	28.08	5.43	0.374	.0520	28.25	5.00	-.053	0.117

Quiz Grades	82.39	15.50	-.0868	0.538	82.95	17.49	-2.061	6.926

Table 11 shows the differences between two conditions at Time 3. This was accomplished by using an independent sample t-test on each of the T3 measures including the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and T2 Quiz Scores. T3 scores did not differ significantly between the two conditions, except for scores on the Awareness scale of the Philadelphia Mindfulness instrument where the treatment group scored significantly higher than the control (see Table 11).

Table 11: Time 3 Group Differences Independent Sample *t*-score and Descriptive Statistics for the Cognitive Test Anxiety Scale, Exam Emotion Regulation Questionnaire, Self-Regulation Scale, Philadelphia Mindfulness Scale, and Quiz Scores at Time three.

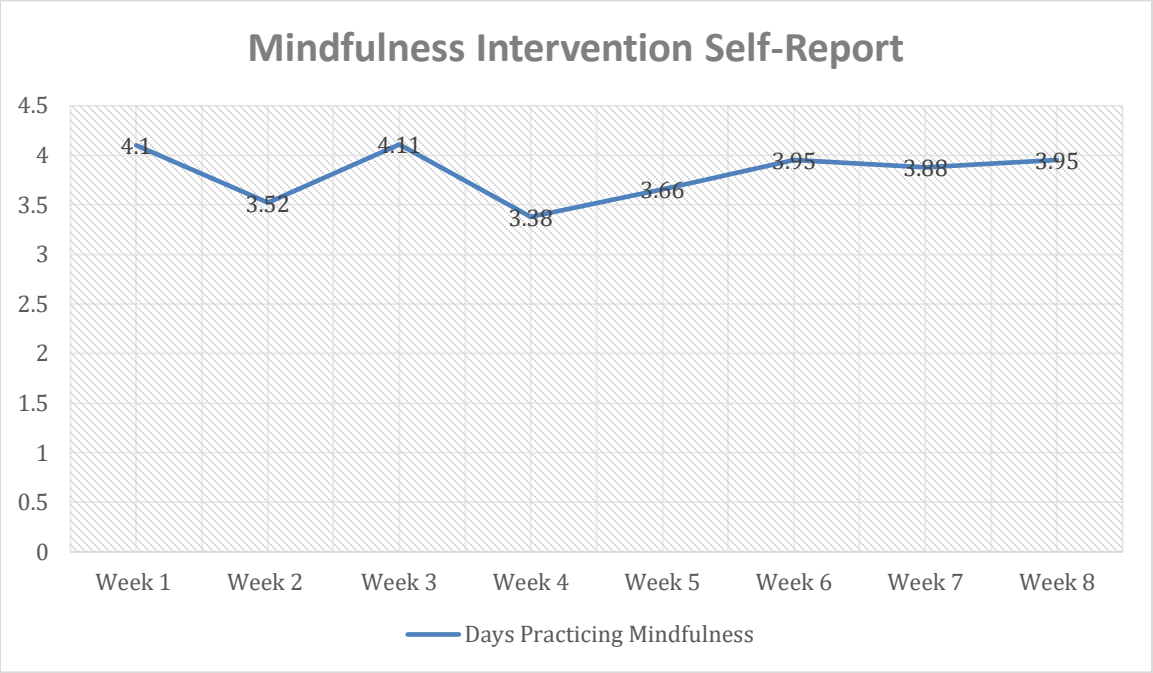
Variable	Treatment Mean	Treatment SD	Control Mean	Control SD	t	P
Test Anxiety	69.82	15.12	69.80	14.69	-0.009	0.993
Emotional Regulation (Total)	37.29	8.22	37.18	6.35	-0.089	0.929
Philadelphia Mindfulness Awareness	37.14	6.23	35.16	5.36	-1.979	0.50
Philadelphia Mindfulness Acceptance	34.01	7.89	34.34	7.06	0.251	0.802

Attention Regulation	28.32	5.48	27.56	5.06	-0.844	0.400
Quiz Grades	82.97	15.11	82.98	16.63	0.003	0.998

This portion of my study was to test (a) whether participants would exhibit significant change over time in test anxiety, mindfulness, emotional regulation, attentional regulation, and assessment grades and (b) whether any observed changes might vary as a function of treatment condition (i.e., exposure to the online mindfulness intervention versus control group. I performed a series of 3 (time) X 2 (treatment condition; tx group versus control group) repeated measures with each of the abovementioned variables as outcome variables.

Participants of the intervention group were given a single item survey each week to self-report their level of participation in the intervention. Participants were asked to self-report the number of days they practiced mindfulness each week, from zero to seven. Results are displayed in Figure 4. Across eight weeks the average number of participations per week was 3.89 days, slightly more than half. This suggests that on average, participants engaged in the intervention when prompted more often than not.

Figure 4: Weekly Participation Self-Report



Tables 12 through 18 contains results of the factorial analyses used to explore the impact of participating in the online mindfulness intervention. To address question two, both conditions showed changes in test anxiety from T1 to T3. The treatment condition experienced a decrease in scores on the Cognitive Test Anxiety assessment compared to the control group, however, the interaction with the mindfulness training (T1 to T3) was not significant (see Table 12).

Additionally, both conditions experienced changes in their quiz grades from T1 to to T3. The treatment condition experienced a large change from T1 (83.39) to T2 (90.21), but those results returned very close to T1 averages at T3 (83.01). The control condition demonstrated an overall increase in assessment scores from T1 (77.67) to T3 (83.04). There was no statistically significant difference with the interaction with mindfulness training on quiz score grades from T1 to T3, (see Table 13).

Changes in test anxiety scores are perhaps supported by the changes in attentional regulation scores as measured by the Self-Regulation scale. The control group showed a modest decline in attentional regulation scores from T1 (28.39) to T3 (27.64) while the treatment group

showed a modest increase in attentional regulation scores from T1 (27.80) to T3 (28.12). The interaction of time, however, was not statistically significant, (see Table 14).

Similar results occurred with emotional regulation scores as measured by the Exam Emotion Regulation Questionnaire. Both conditions showed a modest increase in emotional regulation scores from with the control increasing from 35.78 (T1) to 36.42 (T3) while the treatment group increased in emotional regulation scores from 36.44 (T1) to 38.39 (T3). The interaction of time, however, was not statistically significant, (see Table 15).

Finally, in regard to mindfulness scores from T1 to T3, both conditions showed modest changes in mindfulness as measured by the Philadelphia Mindfulness Scale divided into two subscales, Acceptance and Awareness. There was virtually no difference in the interaction of mindfulness training between conditions on the Acceptance subscale, and therefore any difference obtained was not significant, (see Table 16). The same results occurred with the Awareness variable. There was slight variation with the treatment group scoring slightly higher from T1 to T3, but the interaction was not statistically significant, (see Table 17).

Table 12: Repeated measures results Test Anxiety

Source	*df*	MS	*F*	*p*	Effect Size
Test Anxiety	1.977	393.677	1.501	0.225	0.316
Time	1	194.629	0.979	0.324	0.166
Test Anxiety × Time	1.977	438.437	1.672	0.190	0.348
Error	241.206	262.297			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

Table 13: Repeated measures results Quiz Scores

Source	*df*	MS	*F*	*p*	Effect Size
Quiz Scores	1.680	1038.88	1.750	0.182	0.333

Time	1	2123.650	3.243	0.074	0.431
Quiz Scores × Time	1.680	721.161	1.215	0.294	0.243
Error	124.000	996.976			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

Table 14: Repeated measures results Attentional Regulation

Source	*df*	MS	*F*	*p*	Effect Size
Attentional Regulation	1.945	12.294	0.391	0.671	0.112
Time	1	2.968	0.127	0.722	0.064
Attentional Regulation × Time	1.945	11.610	0.355	0.695	0.106
Error	245.779	31.430			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

Table 15: Repeated measures results Emotional Regulation

Source	*df*	MS	*F*	*p*	Effect Size
Emotional Regulation	1.918	57.672	1.004	0.365	0.220
Time	1	59.625	1.019	0.315	0.171
Emotional Regulation × Time	1.918	44.652	0.777	0.456	0.179
Error	256.993	110.210			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

Table 16: Repeated measures results Acceptance

Source	*df*	MS	*F*	*p*	Effect Size
Acceptance	1.904	1.698	0.033	0.967	0.055
Time	1	56.692	1.013	0.316	0.170
Acceptance × Time	1.904	263.940	5.915	0.007*	0.812
Error	238.044	50.809			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

Table 17: Repeated measures results Awareness

Source	*df*	MS	*F*	*p*	Effect

					Size
Awareness	1.962	2.946	0.093	0.908	.064
Time	1	56.777	1.825	0.179	0.268
Awareness × Time	1.962	60.722	1.915	0.150	0.392
Error	245.284	31.376			

Note—MS=Mean squares, effect size=η^2 or partial η^2. *p<.05.

As manipulation checks prior to the intervention, participants were also assessed on their previous experience practicing mindfulness and were given the examples of meditation and yoga for reference. Of the 150 participants enrolled in this study, 61(40.6%) responded with "Yes" while 89 participants (59.33%) responded with "No" (see Figure 5). Additionally, participants were asked to evaluate their own motivation to reduce test anxiety on a five-point Likert scale with 1 representing "Not at all", 3 representing an anchor point of "A moderate amount" and 5 representing "A Great Deal". Out of 150 participants, only 12 self-reported a score of 1, indicating that most of the participants have experienced or are currently experiencing test anxiety to some degree (see Figure 6).

Figure 5: Previous Mindfulness Experience

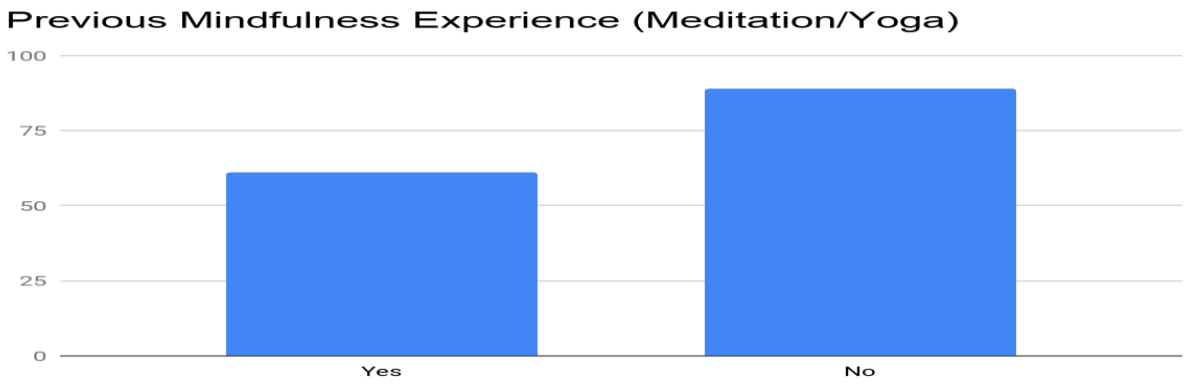
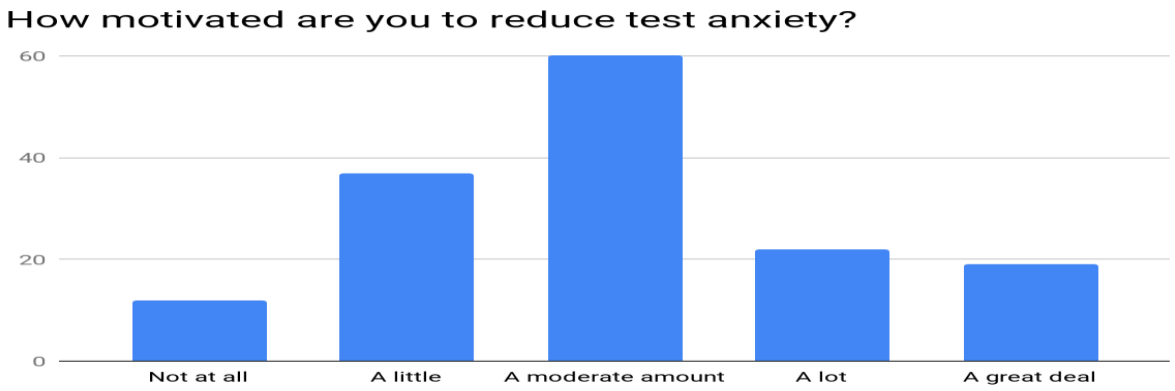


Figure 6: How motivated are you to reduce test anxiety?


How motivated are you to reduce test anxiety?
60
40
20
0
Not at all
A little
A moderate amount
A lot
A great deal

CHAPTER FIVE

DISCUSSION

Summary of Findings

The goal of this research was twofold: 1) to explore the theoretical relationships between the constructs of mindfulness, emotional regulation, attentional regulation, and test anxiety and 2) to examine the impact of an online mindfulness-based intervention with introductory physics students. Results from SEM path analysis suggests that the attentional regulation component of mindfulness was a strong, significant predictor of both test anxiety and grades at T1. Exploring the indirect effects revealed that both T1 Acceptance and Awareness on T1 Quiz grades flowed through the variable of attentional regulation, however, these indirect effects were not significant. Compared to attentional regulation, emotional regulation had very little predictive power for test anxiety or grades at T1 as was removed from the final iterations of the model.

Additionally, results from repeated measures ANOVA revealed that the mindfulness intervention did not have a significant effect on reducing test anxiety and improving quiz scores. Results of this study have both theoretical and practical implications.

Theoretical Implications

To begin, this research supports the existing literature establishing connections between assessment performance and test anxiety, with students experiencing higher levels of test anxiety also performing lower on assessments (Chappel et al. 2005; Barrows, Dunn, & Lloyd, 2013). Across five structural equation path models, test anxiety scores as a direct effect at T1 were consistently a significant negative predictor of quiz grades at T1, suggesting that the more students experience test anxiety the more detrimental that experience is to their assessment results. These results are important in physics education because previous research from Cassady

(2001) suggests that the experience of test anxiety is consistent throughout a college semester. These results were obtained from T1 data at the beginning of the semester, suggesting that perhaps the experience of test anxiety is negatively impacting student assessment performance throughout the semester. This is especially important in an introductory physics course because the course content tends to build in complexity as students move through the course. This implies that finding ways to combat the experience of test anxiety early in the semester, rather than later could benefit those students impacted most by the experience of test anxiety.

Results of this research affirm my beliefs that college physics courses, especially at the introductory level with less experienced college students, are associated with a large amount of test anxiety (Dawood et al., 2016). More than half of the students enrolled in this study self-reported at least a moderate amount of test anxiety or greater towards physics exams at T1. This supports previous research by Huberty (2009) that suggests *at least 30%* of students in any given class will experience test anxiety to some degree. Younger college students, such as freshman and sophomores, are already prone to experience more test anxiety than older college students (Dawood et al, 2009), but the problem may be compounded in a physics course that often confronts students with their first exposure to scientific thinking in a critical and systematic way (Redish, Saul, & Steinberg, 1998). Results of this research suggest that Huberty's (2009) estimate of 30% may in fact be a conservative estimate of the prevalence of test anxiety in introductory physics courses. These findings are startling given how large introductory STEM courses like Introductory Physics tend to be. Enrollment numbers in introductory physics courses regularly exceed 100 students. Even if only 30% of students in a typical Introductory Physics class experience test anxiety that is still 30 potential students who will be at a disadvantage when taking class assessments compared to their peers who do not experience test anxiety. These

results are important for physics education because they imply that students enrolled in physics courses could theoretically benefit from access to resources, including interventions, that can be used to reduce the experience of test anxiety. Additionally, these findings also are even more startling given how high attrition rates can be in STEM related fields (Sithole et al, 2017). While I have not come across specific research that addresses the relationship between test anxiety and attrition rates, I would hypothesize that greater amounts of test anxiety would likely increase the odds of dropping out of STEM related course and programs.

The findings add to the existing literature on how mindfulness should be conceptualized when developing interventions based around this construct. Bishop and colleagues (2004) define mindfulness as a two-factor construct experienced in terms of self-regulation of attention towards the present moment and an openness towards emotional experiences happening in the present moment. With this conceptual understanding of mindfulness, I used a two-factor instrument of mindfulness with the Philadelphia Mindfulness Scale (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008) that captures each of these elements as defined by Bishop and colleagues (2004). I predicted that both constructs would have strong predictive power in regard to test anxiety scores and grades at T1. Results from five structural equation path models verified that attentional regulation, as measured by the Self-Regulation Scale (Diehl, Semegon, & Schwarzer, 2006), was a significant predictor of both test anxiety and grades at T1.

These results are not surprising given previous research linking mindfulness with positive outcomes in ability to regulate attention (Jha, Krompinger, & Baime, 2007; Flook et al, 2010). Those who are more able to maintain their attention in the present could use these skills before during, or after examination to reduce the impact of test anxiety. Practicing mindfulness through activities such as focused attention meditation (Lutz, Slagter, Dunne, & Davidson, 2008),

emphasize bringing attention to the breath can aid students by making it easier to recognize when their attention has wandered away from the task at hand while also providing an anchor to come back to in the present (Rahl et al., 2016; Lutz, Slagter, Dunne & Davidson, 2008), thus potentially improving academic outcomes in the form of reduced test anxiety and increased quiz grades for students dealing with test anxiety.

What was surprising from these results, however, is that emotional regulation played very little role in the prediction of test anxiety or grades at T1. Ultimately, removing the component of emotional regulation from the theoretical model used for the path analysis was the tipping point of a model that fit the data. This alone should not completely rule out emotions playing some part of the experience between mindfulness and test anxiety. Previous research has shown that mindfulness can have positive impacts on emotional experiences and overall well-being (Maloney, Lawlor, Schonert-Reichl, & Whitehead, 2016; Kiken & Shook, 2012; Menezes & Bizarro, 2015). These results might be explained by the instrument used for measuring emotional regulation, The Exam Emotion Regulation Questionnaire. While this instrument was intended to measure the construct of emotional regulation some of the items blurred the lines between cognition and emotion. Additionally, this instrument had questionable reliability scores before and after this study results may have been skewed.

Another consideration is the construct chosen to assess the emotional aspects of mindfulness. Perhaps instead of emotional regulation as the construct of investigation, it would be more beneficial to look at emotions through the lens of affect regulation more broadly, and stress reduction more specifically. Another consideration is to examine the topic of emotions within the context of achievement emotions found in academic settings such as interest, enjoyment, or boredom (Pekrun & Linnenbrink-Garcia, 2012).

Gross (2015) places emotional regulation under a broad umbrella of general affect regulation. Affect as defined by Gross (2015), includes how individuals respond to stress, emotions, and moods. Furthermore, under the umbrella of affect regulation includes coping with stress, emotional regulation, and mood regulation. Gross (2015) points out that while there is some overlap between coping with stress and emotional regulation, they are distinct constructs in that coping with stress generally refers to reducing the stress response experience and negative affect associated with that response instead of attempting to experience or express a specific emotion that takes place with emotional regulation. When being mindful, the goal is not necessarily to change the emotion like one would do with emotional regulation strategies (Grandey, 2000), but rather the point of being mindful in terms of emotions, is to be comfortable and present with whatever emotional experiences are happening in the present moment without trying to alter or change those experiences, regardless of valence. This type of experience is strongly associated with stress reduction (Kabbat-Zinn, 2003).

From a physiological standpoint, simply breathing in and breathing out in a purposeful manner while attempting to remain grounded in the present has tremendous effects on the body in terms of stress reduction (Shanok et al, 2019). This type of activity moves the body from “fight-or-flight”, the body's natural stress response, to “rest-and-digest”, the body’s natural way of coping with stress. This could be conceptualized as a form of coping with strong emotional experiences like stress or anxiety related to testing. This could also be splitting “affective hairs” but understanding the active theoretical ingredients of mindfulness is absolutely critical for developing future mindfulness-based interventions that promote academic outcomes. This research potentially takes the field of mindfulness research one step closer to understanding those active ingredients and how they can be useful for promoting positive academic outcomes

for students. Based on the results from this study I would revise the theoretical model to include other affective related variables such as coping with stress in place of emotional regulation.

Finally, these results have theoretical implications for the field of educational psychology. As more and more mindfulness-based research is conducted in school settings there is a growing need for mindfulness interventions to be grounded in constructs related to educational outcomes. By implementing a mindfulness-based intervention grounded in existing constructs from educational psychology, using the variables of emotional and attentional regulation, I was able to isolate which of these variables would have a significant effect on reducing test anxiety and improving assessment grades in Introductory Physics II. In this case the variable that had the most impact on learning outcomes was attentional regulation.

Practical Implications

From a practical standpoint, this research builds on the growing amount of literature on developing mindfulness-based interventions to address academic outcomes in school settings (Schonert-Reichel & Roeser, 2016; Diamond & Lee, 2011; Flook, Goldberg, Pinger & Davidson, 2015; Goodman, Kashdan, Mallard, & Schumann, 2014; Benn, Akiva, Arel, & Roeser, 2012). However, the findings of my research draw into question the effectiveness of using a mindfulness-based intervention in classroom settings. For example, this research draws into question the findings from previous research using mindfulness to address test anxiety (Cho et al, 2019). The intervention I used to facilitate the development of mindfulness was eight weeks in length, while the intervention used by Cho and colleagues (2019) was only a single week in length. They also did not measure the construct of mindfulness directly and only used participants who self-reported high levels of test anxiety. My research attempted to expand upon Cho and colleagues' (2019) research by measuring mindfulness directly as a two-factor

construct, specifically the factors of Awareness and Acceptance, and using a complete range of test anxiety. However, results revealed no difference between the treatment and control conditions on the measured variables. Given the modifications in my own research made from Cho and colleagues (2019), it appears that the length of the intervention and/or the tasks used in the intervention were not sufficient enough to facilitate mindfulness as predicted. From a practical standpoint this suggests to me that while there is a large growing body of research using mindfulness-based interventions to enhance educational outcomes, researchers should be very cautious in how they develop those interventions and also how the results are interpreted. It is entirely possible that under the right conditions that a mindfulness intervention could facilitate changes in test anxiety, but it is also possible that it could have no effect either based on the findings obtained in my research.

Additionally, this study took place during the COVID-19 global pandemic. Time 1 data was collected prior to the pandemic, but Times 2,3 were collected during the pandemic. The university that I collected data from transitioned from in-class to online instruction due to the pandemic. This transition of classroom settings and the global pandemic likely had a large impact on student stress and perhaps even their experience of test anxiety, given how quickly all of this came about during the semester. These results suggest to me that there is a chance all students in this study experienced a heightened degree of general stress that could potentially render the intervention ineffective.

Another practical implication from this study is that participants were given assessment on different topics and in completely different formats of physics as the semester progressed, based on the COVID-19 outbreak. While the topics in each unit and assessment build upon each other from one assessment to the next, results could imply that improvement occurred from one

assessment to another for other reasons beyond the scope of this intervention such as familiarity with the assessment style, changes in study and preparation habits, or simply maturation across time in the course. Additionally, in place of a quiz during T2, participants were given an online discussion topic instead of a quiz assessment because students could not meet on campus due to the COVID-19 outbreak. The quiz scheduled at T2 was delayed and students were given a discussion topic to work on from home in place of their assessment. While the discussion topic was described by the classroom instructor as being more difficult than typical classroom assignments, it was completed in groups instead of individually, and is perhaps not comparable to the assessment given at T1 and T2. Practically speaking, this makes evaluating the effectiveness of the mindfulness-based intervention on quiz grades difficult.

Another practical implication from this study comes from the assessment instruments used to collect data on the construct of test anxiety. Practically speaking, it may not make sense to measure the construct of test anxiety in a unidimensional fashion. For this study I used the Cognitive Test Anxiety Scale (Cassaday & Johnson, 2001) to measure the construct of test anxiety. As stated previously, this assessment defines test anxiety as a unidimensional construct, focusing exclusively on the cognitive aspects, such as wandering and ruminating thoughts. Perhaps this is why emotional regulation as measured by the Exam Emotion Regulation Questionnaire (Levine, Schmidt, Kang, & Tinti, 2012) showed very little predictive power towards test anxiety using this scale. Of the 27 items on the Cognitive Test Anxiety Scale, over half of these items use words that carry affective meaning such as “worry”, “calm”, and “nervous”, but this instrument was intended to specifically capture the cognitive aspects of test anxiety. To find more predictive power from emotional regulation in relation to mindfulness and test anxiety, it would perhaps be more beneficial to explore other instruments that measure test

anxiety, specifically an instrument that focuses on more than the cognitive aspects of test anxiety, but also physiological and affective. Another possibility is that it might be better to find a different assessment for emotions and affect, such as an instrument that measures the experience of stress or perceived stress.

In terms of the path analysis portion of this research, positive results in term of decreases in test anxiety appear to be most related to changes in participants' attentional regulation and awareness of attention as measured on the Philadelphia Mindfulness Scale. These results have important practical implications for how mindfulness interventions should be developed towards obtaining scientifically sound results. Practically speaking, researchers using interventions that incorporate elements of mindfulness to address academic outcomes should be certain that their expected outcomes are aligned with both their conceptualization of mindfulness and how the intervention is structured to facilitate mindfulness. For example, when attempting to address the cognitive aspects of test anxiety, such as thoughts wandering during testing (Salend, 2010), a mindfulness intervention could be developed around attention training through practices like focused- attention meditation as a potential useful starting point for an intervention grounded in theory (Lutz, Slagter, Dunne, & Davidson, 2008). In my research, I attempted to ground my conceptualization of mindfulness in my study by aligning my expected outcomes with theoretically defensible intervention practices. For example, I used focused attention meditation to facilitate the experience of attentional regulation and open-monitoring meditation to facilitate emotional regulation, and the results suggest that not all of my hypotheses were verified. The experience of mindfulness in regard to test anxiety seems to be strongly facilitated by the ability to maintain attention in the present, while emotional regulation had very little predictive power.

Limitations

No research endeavor is without limitations. All data for this research except for quiz scores were collected in the form of self-report measures. While self-report measures are a valuable tool and effective method for gathering participant data, there is a possibility that participants responded positively to the instruments out of social desirability or perhaps complying to the requests made within the study. Even with asking participants once per week to self-report on how often they participated in the intervention, I cannot be completely certain how often participants actually engaged in all of the various elements of the mindfulness intervention. A possible outcome is that some participants participated engaged fully in the intervention by reading each of the articles I sent and complying with the prompts to practice mindfulness while other participants may have engaged only partially or did not engage at all.

Future Directions

There are numerous future directions that follow from the findings of this research. I will review and discuss three potential areas of future research exploring mindfulness and test anxiety including: 1) exploring the relationship between mindfulness training and test anxiety with other academic populations including adolescents and elementary students 2) using experience sampling methods to gain a better understanding of when mindfulness training is most effective at reducing test anxiety and 3) exploring the relationship between emotional regulation, mindfulness, and test anxiety with an instrument that more explicitly captures the affective elements of test anxiety or one that measures coping with stress instead of emotional regulation.

My dissertation research explored the relationship between mindfulness and test anxiety with college students. However, test anxiety is experienced by students at all academic levels, not just in college (Salend, 2010). Based on the results, I hypothesize that it would be worth

exploring the effectiveness of mindfulness-based interventions, especially interventions that can be delivered online, that target younger student populations such as adolescents in middle and high school. Research by Lillard (2011) suggests that mindfulness-based interventions in school settings can be adapted to be appropriate for students of all age groups. I would like to continue this line of research but with students at different levels of educational experience including adolescence, who may benefit from mindfulness based interventions given that this period of development is considered to be a time of storm and stress (Roeser & Pinela, 2014).

Another future direction to take research exploring mindfulness and test anxiety is to explore other sampling methods for measuring the outcomes of mindfulness-based research that targets test anxiety as an outcome. My dissertation research attempted to capture participants' experience of practicing mindfulness before training began, during training, and again after training concluded. Research exploring mindfulness-based interventions might also benefit from assessing the experience of mindfulness closer to when participants are actually practicing the skills they are taught through a mindfulness-based intervention, including their assessment throughout their day-to-day lives during the intervention. Experience sampling method (ESM) offers some guidelines for how this type of assessment could be accomplished. ESM has the potential to reveal more nuance about how participants are experiencing mindfulness in the moment throughout an intervention. For example, ESM was used successfully by Nakamura and Csikszentmihalyi (2014) to assess the construct of flow as this construct occurs in a participants' everyday experience. Participants were surveyed at multiple times throughout a longitudinal study with results revealing important information about the frequency and intensity of participants' thoughts, behaviors, and emotions across time. This type of information could be very useful to future researchers exploring the impact of mindfulness-based interventions by

examining when they might be most effective for reducing test anxiety and improving grades on academic assessments.

Finally, given that emotional regulation had very little predictive power in the proposed model and because the Cognitive Test Anxiety measures test anxiety as a unidimensional construct, future research exploring the topic of test anxiety and mindfulness would benefit by using a different instrument to capture the experience of test anxiety. Perhaps future researchers exploring this topic could use an instrument that captures both the affective and cognitive components of test anxiety, such as the Test Anxiety Measure for College Students, which measures this construct on a number of dimensions including affective, cognitive, and behavioral (Lowe, 2018). This is important to future research because using a multidimensional assessment of test anxiety could perhaps increase the predictive power of the affective component associated with mindfulness.

Contributions and Significance

This research fills a gap in the literature by creating an online mindfulness-based intervention that targeted test anxiety in physics students. Previous research by Cho and colleagues (2019) used a self-taught mindfulness-based intervention to address test anxiety in college students, however, their research only included participants with high self-reported test anxiety. Additionally, their intervention only lasted a single week and did not measure the construct of mindfulness directly. Findings from the intervention portion of this study did not result in significant changes of test anxiety, suggesting that eight weeks was not enough time to facilitate the skills of mindfulness

This research also adds to the existing research literature on mindfulness by exploring the way in which mindfulness is conceptualized for the purposes of facilitating a mindfulness-based

intervention. This research was guided by Bishop and colleagues' (2004) two-factor construct of mindfulness being defined by 1) self-regulation of attention towards the present moment and 2) an open curiosity towards what happens in the present moment. I hypothesized that these two dimensions represented elements of attentional regulation and emotional regulation, respectively. Using five structural equation path models, results suggests that attentional regulation played a significant role in predicting test anxiety and quiz grades, while emotional regulation played very little part in the overall model fit. This is important for future interventions using elements of mindfulness because future interventions should be developed in which the theoretical conceptualization of mindfulness and predicted outcomes are in line with one another, and therefore can be justified.

Conclusions

The goal of this research was to explore the theoretical bounds of how mindfulness is conceptualized in educational settings. Additionally, I also used an eight-week online based mindfulness intervention, attempting to reduce test anxiety and to improve quiz grades with Introductory Physics II students. Results of five path models suggest that attention regulation played the biggest predictive role in the experience of mindfulness, reducing test anxiety, and improving grades in physics students. The construct of emotional regulation, on the other hand, had very little predictive power and was ultimately removed from the path models. Additionally, findings of this research suggest that the online-mindfulness intervention facilitated greater reduction in student test anxiety, albeit a non-significant difference. These results have both theoretical and practical implications. Specifically, this research adds to the literature on how future mindfulness interventions should be structured, implying that the intervention design and expected outcomes should be theoretically related to one another. Furthermore, this research also

suggests that educators should be cautious using mindfulness-based interventions in STEM related settings.

References

Arana, F. and Furlan, L. (2015). Groups of perfectionists, test anxiety, and pre-exam coping in Argentine students. *Science Direct.* Retrieved from https://www.sciencedirect.com/science/article/pii/S0191886915300222

Baer, R. A., Smith, G. T., & Allen, K. B. (2004). Assessment of mindfulness by self-report: The Kentucky Inventory of Mindfulness Skills. *Assessment*, *11*(3), 191-206.

Barrows, J., Dunn, S., & Lloyd, C. A. (2013). Anxiety, self-efficacy, and college exam grades. *Universal Journal of Educational Research*, *1*(3), 204-208.

Benn, R., Akiva, T., Arel, S., & Roeser, R. W. (2012). Mindfulness training effects for parents and educators of children with special needs. *Developmental psychology*, *48*(5), 1476.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical psychology: Science and practice*, *11*(3), 230-241.

Barrett, L. F., Gross, J., Christensen, T. C., & Benvenuto, M. (2001). Knowing what you're feeling and knowing what to do about it: Mapping the relation between emotion differentiation and emotion regulation. *Cognition & Emotion*, *15*(6), 713-724.

Barrows, J., Dunn, S., & Lloyd, C. A. (2013). Anxiety, Self-Efficacy, and College Exam Grades. *Universal Journal of Educational Research*, *1*(3), 204-208.

Brewer, J. A., Van Dam, N. T., & Davis, J. H. (2015). Mindfulness and the Addictive Process: Psychological Models and Neurobiological Mechanisms. In *Handbook of Mindfulness and Self-Regulation* (pp. 185-198). Springer, New York, NY.

Broderick, P. C., & Metz, S. M. (2016). Working on the inside: Mindfulness for adolescents. In *Handbook of Mindfulness in Education* (pp. 355-382). Springer, New York, NY.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of personality and social psychology*, *84*(4), 822.

Cardaciotto, L., Herbert, J. D., Forman, E. M., Moitra, E., & Farrow, V. (2008). The assessment of present-moment awareness and acceptance: The Philadelphia Mindfulness Scale. *Assessment*, *15*(2), 204-223.

Carter, R., Williams, S., & Silverman, W. K. (2008). Cognitive and emotional facets of test anxiety in African American school children. *Cognition and Emotion*, *22*(3), 539-551.

Cassady, J. C. (2001). The stability of undergraduate students' cognitive test anxiety levels. *Practical Assessment, Research & Evaluation*, *7*(20), 1-8.

Cassady, J. C. (2004). The influence of cognitive test anxiety across the learning–testing cycle. *Learning and instruction*, *14*(6), 569-592.

Cassady, J. C., Budenz-Anders, J., Pavlechko, G., & Mock, W. (2001). The Effects of Internet-Based Formative and Summative Assessment on Test Anxiety, Perceptions of Threat, and Achievement.

Cassady, J. C., & Finch, W. H. (2014). Confirming the factor structure of the Cognitive Test Anxiety Scale: Comparing the utility of three solutions. *Educational Assessment*, *19*(3), 229-242.

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary educational psychology*, *27*(2), 270-295.

Chapell, M. S., Blanding, Z. B., Silverstein, M. E., Takahashi, M., Newman, B., Gubi, A., & McCann, N. (2005). Test anxiety and academic performance in undergraduate and graduate students. *Journal of educational Psychology*, *97*(2), 268.

Cho, H., Ryu, S., Noh, J., & Lee, J. (2016). The effectiveness of daily mindful breathing practices on test anxiety of students. *PloS one*, *11*(10), e0164822.

Dawood, E., Al Ghadeer, H., Mitsu, R., Almutary, N., & Alenezi, B. (2016). Relationship between Test Anxiety and Academic Achievement among Undergraduate Nursing Students. *Journal of Education and Practice*, *7*(2), 57-65.

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, *333*(6045), 959-964.

Diehl, M., Semegon, A. B., & Schwarzer, R. (2006). Assessing attention control in goal pursuit: A component of dispositional self-regulation. *Journal of personality assessment*, *86*(3), 306-317.

Edenfield, T. M., & Saeed, S. A. (2012). An update on mindfulness meditation as a self-help treatment for anxiety and depression. *Psychol Res Behav Manag*, *5*, 131-41.

Eum, K., & Rice, K. G. (2011). Test anxiety, perfectionism, goal orientation, and academic performance. *Anxiety, Stress & Coping*, *24*(2), 167-178.

Flook, L., Goldberg, S. B., Pinger, L., & Davidson, R. J. (2015). Promoting prosocial behavior and self-regulatory skills in preschool children through a mindfulness-based kindness curriculum. *Developmental psychology*, *51*(1), 44.

Flook, L., Smalley, S. L., 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*.

Galla, B. M., Kaiser-Greenland, S., & Black, D. S. (2016). Mindfulness training to promote self-regulation in youth: Effects of the inner kids program. In *Handbook of Mindfulness in Education* (pp. 295-311). Springer, New York, NY.

Garland, E., Gaylord, S., & Park, J. (2009). The role of mindfulness in positive reappraisal. *Explore*, *5*(1), 37-44.

Germer, C. (2004). What is mindfulness. *Insight Journal*, *22*(2), 24-29.

Gerwing, T. G., Rash, J. A., Allen Gerwing, A. M., Bramble, B., & Landine, J. (2015). Perceptions and Incidence of Test Anxiety. *Canadian Journal for the Scholarship of Teaching and Learning*, *6*(3), 3.

Goldin, P. R., Morrison, A., Jazaieri, H., Brozovich, F., Heimberg, R., & Gross, J. J. (2016). Group CBT versus MBSR for social anxiety disorder: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *84*(5), 427.

Goodman, F. R., Kashdan, T. B., Mallard, T. T., & Schumann, M. (2014). A brief mindfulness and yoga intervention with an entire NCAA Division I athletic team: An initial investigation. *Psychology of Consciousness: Theory, Research, and Practice*, *1*(4), 339.

Grandey, A. A. (2000). Emotional regulation in the workplace: A new way to conceptualize emotional labor. *Journal of occupational health psychology*, *5*(1), 95.

Gross, J. J. (2015). Emotion regulation: Current status and future prospects. *Psychological Inquiry*, *26*(1), 1-26.

Gross, J J., & Ross A. T., "Emotion regulation: Conceptual foundations." (2007).

Gunaratana, B.H. (2002). Mindfulness in plain english. Updated and expanded edition.

Hanh, T. N. (2016). *How to Live*. Berkely, CA: Parallax Pr.

Hall, P. D. (1999). The effect of meditation on the academic performance of african american college students. *Journal Of Black Studies*, *29*(3), 408.

Henderson, C., & Dancy, M. H. (2009). Impact of physics education research on the teaching of introductory quantitative physics in the United States. *Physical Review Special Topics-Physics Education Research*, *5*(2), 020107.

Heppner, W. L., Spears, C. A., Vidrine, J. I., & Wetter, D. W. (2015). Mindfulness and emotion regulation. In *Handbook of mindfulness and self-regulation*(pp. 107-120). Springer, New York, NY

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in cognitive sciences*, *16*(3), 174-180.

Huberty, T. J. (2009). Test and performance anxiety. *Principal leadership*, *10*(1), 12-16.

Jacobs, S.E., & Gross, J.J. (2014). Emotion regulation in education: Conceptual foundations, current applications, and future directions. In *International handbook of emotions in education* (pp. 193-212). Routledge.

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. Cognitive, Affective, & Behavioral Neuroscience, 7(2), 109-119.

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.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical psychology: Science and practice*, *10*(2), 144-156.

Kamel, O. M. (2018). The Relationship between Adaptive/Maladaptive Cognitive Emotion Regulation Strategies and Cognitive Test Anxiety among University Students. *Online Submission*, *7*(1), 100-105.

Kemeny, M. E., Foltz, C., Cavanagh, J. F., Cullen, M., Giese-Davis, J., Jennings, P., & Ekman, P. (2012). Contemplative/emotion training reduces negative emotional behavior and promotes prosocial responses. *Emotion*, *12*(2), 338.

Kiken, L. G., & Shook, N. J. (2012). Mindfulness and emotional distress: The role of negatively biased cognition. *Personality & Individual Differences*,*52*(3), 329-333

Kristeller, J. L. (2015). Mindfulness, eating disorders, and food intake regulation. In *Handbook of mindfulness and self-regulation* (pp. 199-215). Springer, New York, NY.

Lantieri, L., Nambiar, M., Harnett, S., & Kyse, E. N. (2016). Cultivating inner resilience in educators and students: The inner resilience program. In *Handbook of Mindfulness in Education* (pp. 119-132). Springer, New York, NY.

Lau, M. A., Bishop, S. R., Segal, Z. V., Buis, T., Anderson, N. D., Carlson, L., Shapiro, S., Carmody, J., & Devins, G. (2006). The Toronto mindfulness scale: Development and validation. *Journal of clinical psychology*, *62*(12), 1445-1467.

Lawlor, M. S. (2016). Mindfulness and social emotional learning (SEL): A conceptual framework. In *Handbook of mindfulness in education* (pp. 65-80). Springer, New York, NY.

Levine, Linda J., Schmidt, Susanna, Kang, Hannah S., & Tinti, Carla. (2012). Remembering the silver lining: Reappraisal and positive bias in memory for emotion. Cognition and Emotion, Vol 26(5), 871-884.

Lillard, A. S. (2011). Mindfulness practices in education: Montessori's approach. *Mindfulness*,*2*(2), 78-85

Lippman, Heinzle, & Narciss (2018). Instructional design in the context of internet-based mindfulness interventions. Presented at Annual AERA Conference 2018

Liston, D. P. (2016). On Attentive Love in Education: The Case of Courage to Teach. In *Handbook of Mindfulness in Education* (pp. 221-235). Springer New York.

Lomax, R. G., & Hahs-Vaughn, D. L. (2013). *An introduction to statistical concepts*. Routledge.

Lowe, P. A. (2018). An investigation into the psychometric properties of the Test Anxiety Measure for College Students. *Journal of Psychoeducational Assessment*, *36*(4), 322-336.

Lukoff, D., & Strozzi-Heckler, R. (2017). Aikido: A martial art with mindfulness, somatic, relational, and spiritual benefits for veterans. *Spirituality in Clinical Practice*, *4*(2), 81.

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.

MacKenzie, M. J., & Baumeister, R. F. (2015). Self-regulatory strength and mindfulness. In *Handbook of mindfulness and self-regulation* (pp. 95-105). Springer, New York, NY.

Maloney, J. E., Lawlor, M. S., Schonert-Reichl, K. A., & Whitehead, J. (2016). A mindfulness-based social and emotional learning curriculum for school-aged children: The MindUP program. In *Handbook of mindfulness in education* (pp. 313-334). Springer, New York, NY.

Mani, M., Kavanagh, D. J., Hides, L., & Stoyanov, S. R. (2015). Review and evaluation of mindfulness-based iPhone apps. *JMIR mHealth and uHealth*, *3*(3), e82.

McKibben, S. (2014). The mindful educator. *Education Update*, *56*(11), 1-7.

Menezes, C. B., & Bizarro, L. (2015). Effects of focused meditation on difficulties in emotion regulation and trait anxiety. *Psychology & Neuroscience*, *8*(3), 350.

Morledge, T. J., Allexandre, D., Fox, E., Fu, A. Z., Higashi, M. K., Kruzikas, D. T., & Reese, P. R. (2013). Feasibility of an online mindfulness program for stress management—a randomized, controlled trial. *Annals of behavioral medicine*,*46*(2), 137-148.

Morrison, A. B., & Jha, A. P. (2015). Mindfulness, attention, and working memory. In *Handbook of mindfulness and self-regulation* (pp. 33-45). Springer, New York, NY

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.

Nakamura, J., & Csikszentmihalyi, M. (2014). The concept of flow. In *Flow and the foundations of positive psychology* (pp. 239-263). Springer, Dordrecht.

Parker, A. E., & Kupersmidt, J. B. (2016). Two universal mindfulness education programs for elementary and middle-school students: Master Mind and Moment. In *Handbook of Mindfulness in Education* (pp. 335-354). Springer, New York, NY.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational psychology review*, *18*(4), 315-341.

Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In Handbook of research on student engagement (pp. 259-282). Springer, Boston, MA.

Peleg, O. (2009). Test anxiety, academic achievement, and self-esteem among Arab adolescents with and without learning disabilities. *Learning Disability Quarterly*, *32*(1), 11-20.

Posner, M. I., & Dehaene, S. (1994). Attentional networks. *Trends in neurosciences*, *17*(2), 75-79.

Posner, M. I., & Patoine, B. (2009). How arts training improves attention and cognition. *Cerebrum*, *2009*, 2-4.

Rahl, H. A., Lindsay, E. K., Pacilio, L. E., Brown, K. W., & Creswell, J. D. (2017). Brief mindfulness meditation training reduces mind wandering: the critical role of acceptance. *Emotion*, *17*(2), 224.

Redish, E. F., Saul, J. M., & Steinberg, R. N. (1998). Student expectations in introductory physics. *American Journal of Physics*, *66*(3), 212-224.

Roeser, R. W. (2013). Mindfulness and human development: Introduction to the special issue. *Journal of Human Development*, *10*, 1-11.

Roeser, R. W. (2016). Processes of teaching, learning, and transfer in mindfulness-based interventions (MBIs) for teachers: A contemplative educational perspective. In *Handbook of mindfulness in education* (pp. 149-170). Springer, New York, NY.

Roeser, R. W., & Peck, S. C. (2009). An education in awareness: Self, motivation, and self-regulated learning in contemplative perspective. *Educational psychologist*, *44*(2), 119-136.

Roeser, R. W., & Pinela, C. (2014). Mindfulness and compassion training in adolescence: A developmental contemplative science perspective. *New Directions for Youth Development*, *2014*(142), 9-30.

Roeser, R. W., & Zelazo, P. D. (2012). Contemplative science, education and child development: Introduction to the special section. *Child development perspectives*, *6*(2), 143-145.

Salend, S. J. (2010). Addressing test anxiety. *Teaching exceptional children*, *44*(2), 58-68.

Sayers, W. M., Creswell, J. D., & Taren, A. (2015). The emerging neurobiology of mindfulness and emotion processing. In *Handbook of mindfulness and self-regulation*(pp. 9-22). Springer, New York, NY.

Schonert-Reichl, K. A., & Lawlor, M. S. (2010). The effects of a mindfulness-based education program on pre-and early adolescents' well-being and social and emotional competence. *Mindfulness*, *1*(3), 137-151.

Schonert-Reichl, K. A., & Roeser, R. W. (2016). Mindfulness in Education: Introduction and Overview of the Handbook. In *Handbook of Mindfulness in Education*(pp. 3-16). Springer New York.

Schultz, P. P., Ryan, R. M., Niemiec, C. P., Legate, N., & Williams, G. C. (2015). Mindfulness, work climate, and psychological need satisfaction in employee well-being. *Mindfulness*, *6*(5), 971-985.

Schumacker, R. E., & Lomax, R. G. (2004). *A beginner's guide to structural equation modeling*. psychology press.

Shanok, N. A., Reive, C., Mize, K. D., & Jones, N. A. (2019). Mindfulness meditation intervention alters neurophysiological symptoms of anxiety and depression in preadolescents. *Journal of Psychophysiology*.

Siegel, D. J., Siegel, M. W., & Parker, S. C. (2016). Internal Education and the Roots of Resilience: Relationships and Reflection as the New R's of Education. In *Handbook of Mindfulness in Education* (pp. 47-63). Springer New York.

Sithole, A., Chiyaka, E. T., McCarthy, P., Mupinga, D. M., Bucklein, B. K., & Kibirige, J. (2017). Student Attraction, Persistence and Retention in STEM Programs: Successes and Continuing Challenges. *Higher Education Studies*, *7*(1), 46-59.

Smith, V., & Jelen, M. (2016). Mindfulness activities and interventions that support special populations. In *Handbook of Mindfulness in Education* (pp. 171-190). Springer, New York, NY.

Spielberger, C. D. (2010). Test anxiety inventory. *The Corsini encyclopedia of psychology*, 1-1.

Stahl, B., & Goldstein, E. (2010). *A mindfulness-based stress reduction workbook*. New Harbinger Publications.

Sweet, S. D. & Miles B.S., (2016) *King Calm: mindful gorilla in the city.*Magination Press

Tabachnick, B. G., & Fidell, L. S. (2001). Using multivariate statistics. Allyn and Bacon. *Needham Heights, MA*.

Taxer, J. L., & Gross, J. J. (2018). Emotion regulation in teachers: The "why" and "how". *Teaching and teacher education*, *74*, 180-189.

Teper, R., & Inzlicht, M. (2012). Meditation, mindfulness and executive control: the importance of emotional acceptance and brain-based performance monitoring. *Social cognitive and affective neuroscience*,*8*(1), 85-92.

Younge, J. O., Wery, M. F., Gotink, R. A., Utens, E. M., Michels, M., Rizopoulos, D., & Roos-Hesselink, J. W. (2015). Web-based mindfulness intervention in heart disease: a randomized controlled trial. *PLoS One*, *10*(12), e0143843.

Zajonc, A. (2016). Contemplation in education. In *Handbook of mindfulness in education*(pp. 17-28). Springer, New York, NY.

Zeidner, M. (2014). Anxiety in education. In *International handbook of emotions in education* (pp. 275-298). Routledge.

Zoogman, S., Goldberg, S. B., Vousoura, E., Diamond, M. C., & Miller, L. (2019). Effect of yoga-based interventions for anxiety symptoms: A meta-analysis of randomized controlled trials. *Spirituality in Clinical Practice*.

Appendices

Appendix A

Cognitive Test Anxiety Scale

(A *Not at all typical of me,* B *Only somewhat typical of me,* C *Quite typical of me,* and D *Very typical of me.*)

1. I lose sleep over worrying about physics examinations.
2. While taking an important physics examination, I find myself wondering whether the other students are doing better than I am.
3. I have *less* difficulty than the average college student in getting physics test instructions straight.
4. I tend to freeze up on things like intelligence tests and final exams.
5. I am less nervous about physics tests than the average college student.
6. During physics tests, I find myself thinking of the consequences of failing.
7. At the beginning of a physics test, I am so nervous that I often can't think straight.
8. The prospect of taking a physics test in one of my courses would *not* cause me to worry.
9. I am more calm in physics test situations than the average college student.
10. I have less difficulty than the average college student in learning as- signed chapters in physics textbooks.
11. My mind goes blank when I am pressured for an answer on a physics test.

12. During physics tests, the thought frequently occurs to me that I may not be too bright.
13. I do well in speed tests in which there are time limits.
14. During a physics examination, I get so nervous that I forget facts I really know.
15. After taking a physics test, I feel I could have done better than I actually did.
16. I worry more about doing well on physics tests than I should.
17. Before taking a physics test, I feel confident and relaxed.
18. While taking a physics test, I feel confident and relaxed.
19. During physics tests, I have the feeling that I am not doing well.
20. When I take a physics test that is difficult, I feel defeated before I even start.
21. Finding unexpected questions on a physics test causes me to feel challenged rather than panicky.
22. I am a poor physics test taker in the sense that my performance on a physics test does not show how much I really know about a topic.
23. I am not good at taking physics tests.
24. When I first get my copy of a physics test, it takes me a while to calm down to the point where I can begin to think straight.
25. I feel under a lot of pressure to get good grades on physics tests.
26. I do not perform well on physics tests.
27. When I take a physics test, my nervousness causes me to make careless errors.

Appendix B

Exam-related Emotion Regulation Questionnaire

Items

Please think now of an upcoming physics exam and answer the following questions. During this period, what strategies are you using to cope with the physics exam?

Reappraisal

I try to see the positive aspects of this experience.

I try to learn from this experience.

Distraction

I take my mind off the exam.

I engage in fun activities.

Suppression

I do not show my feelings.

I try to suppress my feelings.

Note. Students rated the extent to which they were using specific strategies using a scale ranging from 0 (not at all) to 10 (extremely).

Appendix C

Self-Regulation Scale

1. I can concentrate on a physics test for a long time, if necessary.
2. If I am distracted from a physics test, I don't have any problem coming back to the test quickly.
3. If a physics test arouses my feelings too much, I can calm myself down so that I can continue with the test.

4. If a physics test requires a problem-oriented attitude, I can control my feelings.
5. It is difficult for me to suppress thoughts that interfere with what I need to do.
6. I can control my thoughts from distracting me from the physics test at hand.
7. When I worry about something, I cannot concentrate on a physics test.
8. After an interruption, I don't have any problem resuming my concentrated style of working.
9. I usually have a whole bunch of thoughts and feelings that interfere with my ability to work in a focused way.
10. I stay focused on my goal and don't allow anything to distract me from my plan of action.

Note. Items were rated on a 4-point scale of 1 (Not at all true), 2 (Barely true), 3 (Somewhat true), or 4 (Completely true).

Appendix D

Philadelphia Mindfulness Scale PHLMS

Awareness

1. I am aware of what thoughts are passing through my mind.

3. When talking with other people, I am aware of their facial and body expressions.

5. When I shower, I am aware of how the water is running over my body.

7. When I am startled, I notice what is going on inside my body.

9. When I walk outside, I am aware of smells or how the air feels against my face.

11. When someone asks how I am feeling, I can identify my emotions easily.

13. I am aware of thoughts I'm having when my mood changes.

15. I notice changes inside my body, like my heart beating faster or my muscles getting tense.

17. Whenever my emotions change, I am conscious of them immediately.

19. When talking with other people, I am aware of the emotions I am experiencing.

Acceptance

2. I try to distract myself when I feel unpleasant emotions.

4. There are aspects of myself I don't want to think about.

6. I try to stay busy to keep thoughts or feelings from coming to mind.

8. I wish I could control my emotions more easily.

10. I tell myself that I shouldn't have certain thoughts.

12. There are things I try not to think about.

14. I tell myself that I shouldn't feel sad.

16. If there is something I don't want to think about, I'll try many things to get it out of my mind.

18. I try to put my problems out of mind.

20. When I have a bad memory, I try to distract myself to make it go away.

Note. All items are rated on a 5-point Likert-type scale (1 = never , 2 = rarely , 3 = sometimes , 4 = often , and 5 = very often) according to the frequency each item was experienced over the past week.

Appendix E

Manipulation Check Items Used in pre-assessment

1. Would you like to participate in the intervention portion of this research? Y/N
2. Do you have previous experience practicing mindfulness, such as meditation or yoga? Y/N
3. How motivated are you to address your test anxiety? 5 point likert scale, 1) none at all , 5) a great deal

Appendix F

Weekly Participation Self-Report Assessment

1. In the last seven days, how many days did you practice mindfulness using the Insight Timer app?

Appendix G

Demographic Information

Age:

Gender:

Race/Ethnicity:

Major(s):

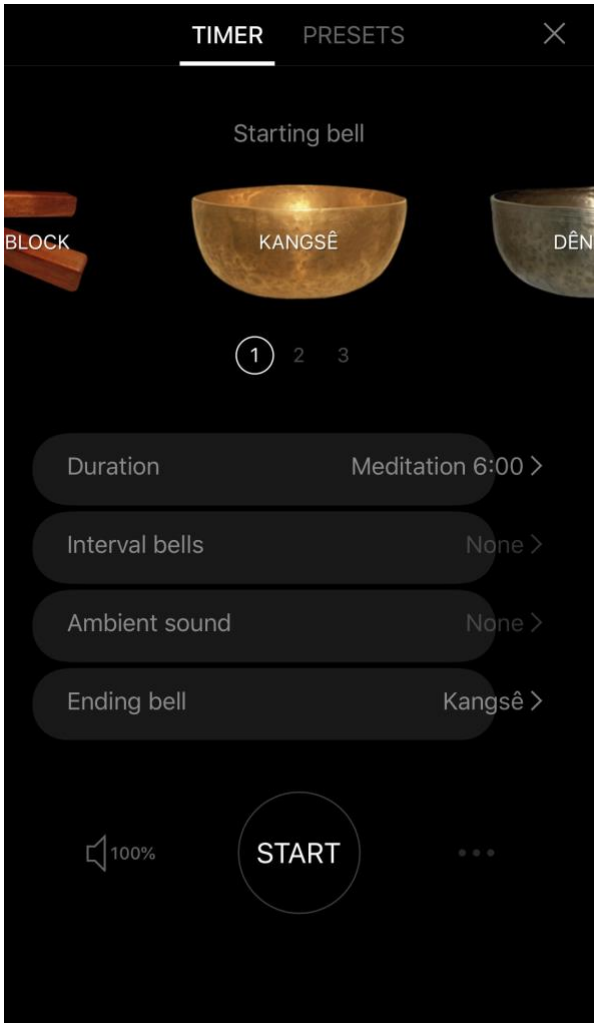
First Generation College Student: Y/N

Number of Hours Enrolled:

Year in School (Freshman, sophomore, etc):

Appendix H

Insight Timer App



Appendix I

Remind Recruit Sign-up

Enter this Number

81010

Text this message

@2gd8kd

Appendix J

T1 Physics Quiz

1) Two point charges of +20.0 μC and −8.00 μC are separated by a distance of 0.20 m. What is the magnitude of electric field due to these charges at a point midway between them?
   A) 25.2×10^4 N/C directed toward the negative charge
   B) 25.2×10^6 N/C directed toward the negative charge
   C) 25.2×10^6 N/C directed toward the positive charge
   D) 25.2×10^5 N/C directed toward the positive charge
   E) 25.2×10^5 N/C directed toward the negative charge

2) A glass bead has been charged to 8.0 nC. What is the magnitude of the electric field 0.020 m from the center of the bead?
   A) 3.6×10^3 N/C B) 1.4×10^6 N/C C) 1.8×10^5 N/C D) 1.4×10^{-3} N/C E) 3.6×10^{-6} N/C

3) What is true about charging insulators and conductors?
   A) Both insulators and conductors can be charged and hold a charge.
   B) Only conductors can be charged and hold a charge.
   C) Neither insulators nor conductors can be charged and hold a charge.
   D) Only insulators can be charged and hold a charge.
   E) Insulators can be charged by bringing a charged object close, but a conductor must make contact with the charged object.

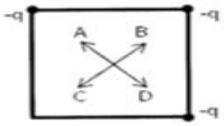
4) When two point charges are a distance d apart, the electric force that each one feels from the other has magnitude F. In order to make this force twice as strong, the distance would have to be changed to
   A) $d/4$. B) $d/\sqrt{2}$ C) $2d$. D) $d/2$. E) $\sqrt{2}d$.

5) Two point charges of equal magnitudes and opposite signs are positioned as shown in the figure. Which of the arrows best represents the net electric field at point P due to these two charges?

   A) A B) B C) C D) D E) field is 0

6) Which of the following is *not* true about plots of electric field lines?
   A) Close enough to any point charge, the electric field lines are radial (pointing in or out depending on the charge).
   B) The density of electric field lines is proportional to the electric field strength.
   C) The electric field is tangent to the electric field line.
   D) Electric field lines cross at positions of zero electric field.
   E) Far enough away from any net charge, the electric field lines are radial (pointing in or out depending on the net charge).

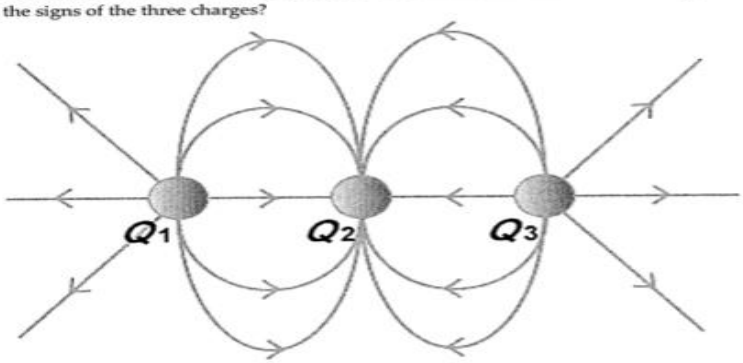
7) Three equal negative point charges are placed at three of the corners of a square of side d as shown in the figure. Which of the arrows represents the direction of the net electric field at the center of the square?



   A) A B) B C) C D) D E) The field zero.

8) Charge $Q_1 = 6.0$ μC is at (0.30 m, 0), charge $Q_2 = -1.0$ μC is at (0, 0.10 m), and charge $Q_3 = 5.0$ μC is at (0, 0). What is the magnitude of the net electrostatic force on the 5.0−μC charge due to the other charges?
   A) 3.6 N B) 7.3 N C) 9.1 N D) 4.9 N E) 5.4 N

9) The figure shows three electric charges labeled Q_1, Q_2, Q_3, and some electric field lines in the region surrounding the charges. What are the signs of the three charges?



A) Q_1 is positive, Q_2 is negative, Q_3 is positive.
B) Q_1 is positive, Q_2 is positive, Q_3 is negative.
C) Q_1 is negative, Q_2 is positive, Q_3 is negative.
D) All three charges are negative.
E) All three charges are positive.

10) Charge Q_1 = 4 nC is at the origin and charge Q_2 = –9.0 nC is at position (0 m, 4 m). The *y* component of the electric field, at position (3 m, 0 m), is closest to
A) -2.59 N/C B) -1.44 N/C C) 2.59 N/C D) 1.44 N/C E) 0 N/C

11) *X* and *Y* are two uncharged metal spheres on insulating stands, and are in contact with each other. A positively charged rod *R* is brought close to *X* as shown in Figure (a). Then, sphere *Y* is moved away (*X* and R don't move), as in Figure (b). What are the final charge states of *X* and *Y*?

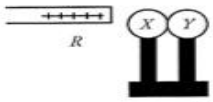


Figure (a)

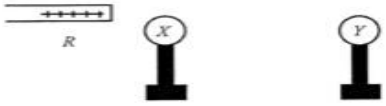


Figure (b)

A) Both *X* and *Y* are negative.
B) Both *X* and *Y* are neutral.
C) *X* is positive and *Y* is neutral.
D) *X* is neutral and *Y* is positive.
E) *X* is negative and *Y* is positive.

12) Two objects are brought near each other, but not touching. One is charged, but the other is an insulator and not charged. Which of the following is true?
A) The charged object polarizes the insulator creating an attractive force.
B) There is a slight attractive force only if the first one is positively charged.
C) There is a slight repulsive force only if the first one is negatively charged.
D) The charged object polarizes the insulator creating a repulsive force.
E) There is no force between the objects because one is neutral.

Appendix K

T2 Discussion Assignment

Physics 2524

Consider the following circuit: It is comprised of two concentric, semicircle wire elements of radius a and b. They are connected by wire segments that run radial to the circles. The point, P is at the shared center of their circles. The Biot-Savart for a current element is given by:

$d\vec{B} = \mu o I d\vec{l} \times \hat{r}, (1) 4\pi r2$

where $\vec{r}$ is the vector that points from the current element to the point where you are calculating the magnetic field. We want to calculate the field at point P.

(a) Draw a picture of the circuit.

(b) Start with the outer curve. Choose a random infinitesimal length, $d\vec{l}$ along the outer loop. Draw the vector $\vec{r}$ from that element to the point P. What is the magnitude of $\vec{r}$? Note the directions of both $d\vec{l}$ and $\vec{r}$. Calculate $d\vec{l} \times \vec{r}$. Use these to calculate the amount of magnetic field created, $d\vec{B}$.

(c) Choose another random infinitesimal length along the upper curve and repeat the steps. How does the answer similar and different?

(d) Now integrate your expression for $d\vec{B}$ along the outer curve.

(e) Repeat the process for the inner curve.

(f) What is the contribution to the field from the radial wire segments? Why?

(g) What is the total magnetic field at point P?

Physics 2524

The circular motion of charges in a constant magnetic field has many applications, from laboratory experiments to microwave ovens. In this discussion you'll consider one of the scientific applications of this "cyclotron motion", the mass spectrometer.

In the mass spectrometer, atoms (the small circles) of mass m are positively charged by removing one electron (for the atoms, $q = +1.6x10^{-19}C$). They are accelerated in a parallel plate capacitor where the electrostatic potential drop from left to right is DV. They then enter a region of constant magnetic field, B, so their trajectory is bent around a quarter of a circle of radius R. If the field B and the potentialDV are correct, they are detected in a metal "Faraday" cup that measures their charge.

A) Draw the free body diagrams for the atoms at the three points marked by small circles (at the left plate of the capacitor, just as the atom enters the B-Field, and halfway around the quarter circle). Assume the electric field is zero outside of the capacitor and the magnetic field is zero outside of the square shown and into the paper inside the square. Be sure to label your forces. Neglect gravity.

B) Using the fact that the acceleration of a particle moving in a circle of radius R with a speed v is v^2/R, find a relationship between the speed of the atom and the B field. In other words, find an equation that gives v in terms of B, R, and other quantities. Explain.

C) Considering that the speed of the atom is determined by the potential on the capacitor, find a relationship between velocity, v, that the atom leaves the capacitor and the potential, DV. In other words, find an equation that gives v in terms of DV and other quantities. Assume the atoms are initially at rest. Explain.

D) Your mass spectrometer is designed for a radius of the atom trajectory, R = 0.20 m in a field B = 0.050 T. If you are trying to detect Carbon atoms (mass of 12 times the proton, proton mass 1.7×10^{-27}kg), what potential DV do you need to put on the capacitor?

E) The power of a mass spectrometer is that only particles of a specific mass will be measured in the detector for a given B, R, and DV. If you had Carbon and Oxygen atoms in the detector as described in part D, would the Oxygen atoms end up to the left of the detector or to the right (in the figure)? What DV would be needed to detect Oxygen atoms? The mass of Oxygen is 16 times the mass of the proton.

Appendix L

T3 Quiz

The emf induced in a coil is proportional to the magnitude of flux through the coil.

A. true

B. false

1. A square wire "loop" with each side having length *a*, surrounds a solenoid of radius *R* that creates a constant magnetic field *B* inside the solenoid only. The plane of the square is perpendicular to the axis of the solenoid and the manetic field. What is the flux through the square wire?

A. zero B. Ba^2 C. $B\pi R^2$

2. A uniform magnetic field is applied perpendicular to the plane of a 60-turn circular coil with a radius of 6.0 cm and a resistance of 0.60 Ω. If the magnetic field increases uniformly from 0.20 T to 1.80 T in 0.20 s, what is the magnitude of the emf induced in the coil?

A. 5.4V B. 7.2V C. 12V D. 16V E. 9.2V

3. A solenoid inductor (self-inductance of 96 mH) is 0.80 m in length and 0.10 m in diameter. A coil is tightly wound around the solenoid at its center (approximately same diameter). The coil's resistance is 6.0 ohms. The mutual inductance between the coil and solenoid is 31 μH. At a given instant, the current in the solenoid is 540 mA and is decreasing at the rate of 2.5 A/s. At this given instant, what is the magnitude of the induced current in the coil?

A. 7.8 μA B. 9.4 μA C. 13μA D. 6.3 μA E. 11μA

4. A circular metal ring is situated above a long straight wire, as shown in the figure. The straight wire has a current flowing to the right, and the current is increasing in time at a constant rate. Which statement is true?

A. There is no induced current in the metal ring because the current in the wire is changing at a constant rate. B. There is an induced current in the metal ring, flowing in a counter-clockwise direction.
C. There is an induced current in the metal ring, flowing in a clockwise direction.

5. A solenoid of length 0.700 m and resistance 2.4 ohms has a self-inductance of 3.37 μH. What is the energy stored in the inductor when a constant current of 0.811 A runs through it?

A. zero B. 1.11 μJ C. 1.37 μJ D. 1.86 μJ E. 2.66 μJ

6. A 2D plane is divided into two haves. In one half, a constant magnetic field of 3 T points out of the page. In the other the magnetic field is zero. A square wire of side 4 m is half-way into the magnetic field region. It is being pulled out with a speed of 5 m/s.

What is the emf enduced in the wire?

A. 15Wb
B. 30Wb
C. 60Wb

D. 120 Wb

E. 240 Wb

F. 480 Wb

7. A 2D plane is divided into two haves. In one half, a constant magnetic field of 3 T points out of the page. In the other the magnetic field is zero. A square wire of side 4 m is half-way into the magnetic field region. It is being pulled out with a speed of 5 m/s.

It what orientation is the current induced in the wire?

A. clockwise
B. counter-clockwise

8. A 2D plane is divided into two halves. In one half, a constant magnetic field of 3 T points out of the page. In the other the magnetic field is zero. A square wire of side 4 m is half-way into the magnetic field region. It is being pulled out with a speed of 5 m/s.

Is there a net force on the wire? If so, in what direction?

A. no net force
B. up
C. down

D. in direction of motion of wire
E. opposite direction of motion of wire

Appendix M

Thich Nhat Hanh Daily Tips

Week One - Focused attention

Day 1

In our daily lives, our attention is dispersed, Our body is in one place, our breath is ignored, and our mind is wandering. As soon as we pay attention to our breath, as we breathe in these three things- body, breathe, and mind, - come together. This can happen in just one or two seconds. You come back to yourself. Your awareness brings these three elements together and you become fully present in the here and the now. You are taking care of your body, you are taking care of your breath, and you are taking care of your mind.

When you make a soup, you have to add together all the right ingredients in harmony and let them simmer. Our breath is the broth that brings the different elements together. We bathe spirit and mind in our breath and they become integrated so they are one thing. We are whole. We don't need to control our body, mind and breath. We can just be there for them. We allow them to be themselves. This is nonviolence.

Day 2 - Meditation

The term for sitting and being aware is sitting meditation. "Zen" is the Japanese pronunciation of dhyana, which is the Sanskrit word for meditation. Meditation is simply the practice of stopping and looking deeply. You do not need to sit to meditate. Anytime you are looking deeply - whether you are walking, chopping, vegetables, brushing your teeth, or going to the bathroom - you can be meditating. In order to look deeply, you need to make the time to stop everything and see what is there.

With mindfulness and concentration you can direct your attention to what is there and have a deep look. You can begin to see the true nature of what is in front of you. What is there may be a cloud, a pebble, or a human being. It may be our anger. Or it may be our own body and its nature of impermanence. Every time we truly stop and look deeply, the result is a better understanding of the true nature of what is there inside us and around us.

Day 3 - Enjoy Your Breathing

When you sit down, the first thing to do is to become aware of your breathing. Becoming aware of your breathing is the first step in taking care of yourself. Becoming aware of your in-breath and out-breath, you can see how your breath moves through your body. You begin to take care of your body and your mind and you begin to find joy in the very simple act of breathing. Every in-breath can bring joy; every out-breath can bring calm and relaxation. This is a good enough reason to sit. We don't need to sit with an intention like getting smarter or becoming enlightened. We can sit just to enjoy sitting and breathing.

Day 4 - The Joy of Meditation

If you ask a child, "Why are you eating chocolate? The child would likely answer, "Because I like it." There's no purpose in eating the chocolate. Suppose you climb a hill and stand on top to look around. You might feel quite happy standing on the hill. There's not a reason for doing it. Sit in order to sit. Stand in order to stand. There is no goal or aim in sitting. Do it because it makes you happy.

Day 5 - Seeing clearly

The first thing to do when you sit down is to pay attention to your in-breath and out-breath. Focus your attention entirely on your breathing. If you truly practice, your breath will become peaceful. This peaceful breathing will soothe both mind and body. This is the first priority of sitting meditation, to help us calm down. Once we are calm, we can see more clearly. And when our vision is no longer clouded, we see with more understanding, and we naturally begin to feel compassion for ourselves and for others. That is when true happiness becomes possible.

Week Two - Open Monitoring

Day 1 - What to Do

Sometimes people say they don't know what to do when they are sitting. "You only need to sit" is an exhortation of the Soto Zen meditation school. It means that you should sit without waiting for a miracle, and that includes the miracle of enlightenment. If you always sit in expectation, you're not in the present moment. The present moment contains the whole of life.

Day 2 - Letting Go

Sit in such a way that you feel light, relaxed, happy, and free. Many of us have so many anxieties and projects that weigh heavily on us. We carry our past sorrows and anger and they become a baggage that makes life heavy. Sitting meditation is a way to practice letting go of the things we carry needlessly. These things are nothing but obstacles to our happiness. Ease in our sitting and ease in our breathing nourishes the body and mind.

When we calm, we can look deeply into a difficult emotion to see its roots and understand it better. FIrst we nourish ourselves with the joy of meditation, calming the body, and thoughts. Then we embrace the difficult feeling. This brings some relief and gives us a more solid basis for investigating and transforming the difficulty so we can get the healing we need.

Finally, we can explore if our emotion is based on something happening in the present or something that we are still attached to from the past. If it's from the past we can begin to let it go, to more truly see and experience the present moment.

Day 3 - Recognizing the Body

When our in-breath and out-breath become peaceful and pleasant, or bodies begin to benefit. In our daily lives, any of us forget that we have a body. Our bodies often contain stress, pain, and suffering. Often we ignore the body until the pain gets too great. If we breathe peacefully, this peace will be transmitted to the body. Sitting and breathing mindfully, we bring the mind back to the body and begin to recognize and release the tension held there.

Day 4 - A River of Feelings

There's a river of feelings in every one of us - pleasant feelings, unpleasant feelings, and neutral feelings. They come one after another like drops of water in the river. As we sit, the river of feelings runs through us and it's tempting to let a strong feeling pull us downstream. Instead, we sit on the riverbank and observe the feelings as they run through us. We can name them. "This is a pleasant feeling." "This is a painful feeling." We can do the same with our mental formations, such as anger and fear. Naming can be the first step in giving us distance from our feelings, so we can see that feeling is just a feeling and that it is impermanent. A feeling comes and eventually it goes.

Day 5 - Weathering the Storm of Strong Emotions

A strong emotion is like a storm and it can create a ton of damage. We need to know how to protect ourselves and create a safe environment where we can weather the storm. Keeping our body and mind safe from the storm is our practice. After each storm, we will become stronger, more solid, and less fearful of the storms.

We can learn to take care of the painful feelings and strong emotions emerging from the depth of our consciousness. We are more than our emotions. We can recognize what is there. "Breathing in, I know that this is only an emotion. It's not the whole of me. I am more than my emotions." This is a very basic insight. Emotions will manifest, stay for awhile, and then leave. Why should we die because of one emotion? After a few minutes of practice the storm will die down, and you will see how easily you have survived. You should start your practice before the storm begins or you might forget to do it, and may get carried away by the storm. This is why our daily practice is important.

Week Three - Mindful Eating

Day 1 - Mindful Eating

To cultivate mindfulness, we can do the same things we always do the same things we always do - walking, sitting, working, eating, and so on - with mindful awareness of what we are doing. When we're eating, we know that we are eating. When we open a door, we know that we're opening a door. Our mind is with our actions.

When you put a piece of fruit into your mouth, all you need is a little bit of mindfulness to be aware: "I am putting a piece of apple in my mouth." Your mind doesn't need to be somewhere else. If you're thinking of work while you chew, that's not eating mindfully. When you pay attention to the apple, that is mindfulness. Then you can look more deeply and in just a very short time you will see the apple seed, the beautiful orchard and the sky, the farmer, the picker, and so on. A lot of work is in that apple!

Day 2 - Eating Without Thinking

When we eat we usually think. We can enjoy our eating a lot more if we practice not thinking when we eat. We can just be aware of the food. Sometimes we eat and we're not aware that we're eating. Our mind isn't there. When our mind isn't present, we look but we don't see, we listen but we don't hear, we eat but we don't know the flavor of the food. This is a state of forgetfulness, the lack of mindfulness. To be truly present we have to stop our thinking. This is the secret of success.

Day 3 - One Mindful Breath

It only takes one moment to take a mindful in-breath and out-breath before you eat. Bring the mind back to the body. Your body is always available to you. You can bring your attention out of your head and into your body. Before you focus on the food, focus being present with your body: "Breathing in, I am aware that my body is still there. Breathing out I am smiling to my body." This body has been given to us by our parents and those before them. When this body was just born, it was very light. As we grow, we tend to get weighed down by worries and lose our freshness and beauty. Mindful eating helps us regain the freshness nourishing our spirits as well as our bodies. Eating with appreciation of our own bodies, we eat with more relaxation and joy.

Day 4 - A Silent Meal

Happiness is possible during the meal, and silence helps enormously. You may want to pick one meal a week to eat in silence. A silent meal helps you come back to yourself and arrive in the present moment. A truly silent meal includes turning off the noise in your head as well as finding a quiet place to enjoy your meal. You may like to choose to eat the same meal every week silently. This can be a meal you eat by yourself or, if you have family or friends who want to join you for this meal, that is wonderful. Silence helps you return to your mindful breathing. You can stop the internal mental chatter, relax, breathe, and smile. Such a meal can provide many moments of happiness.

The Right Amount

Mindfulness of eating helps us to know what and how much we should eat. We should take only what we can eat. We tend to ignore the rule of moderation. Many of us should take less than what we're used to eating every day. We see that people who consume less are healthier and more joyful, and that those who consume a lot may suffer very deeply. If we chew carefully, if we eat only what is healthy, then we won't bring sickness into our body or our mind.

Week Four - Mindful Walking

Day 1 - Creating a Habit of Mindful Walking

Every time you need to go somewhere, even if it's a very short distance of three or five steps, you can apply mindful walking. Soon it will become a habit. You will find that you are walking mindfully to pick up the phone or to make you tea. You may not realize at first why you don't feel rushed or why you are happier when you walk in the door. Cultivating a daily habit of walking meditation is free and it doesn't take any more time than the walking you are already doing.

Day 2 - Listen to Your Lungs

Let your own lungs determine your breathing. Never force your breath. When walking, match your steps to your breath, not the other way around. You might begin by taking two steps for your in-breath and three steps for your out-breath. If, as you continue to walk, your lungs say they'd be happier making three steps while breathing in and five steps while breathing out, then you make three steps and five steps. Of course when you're climbing a hill, the number of steps you can take with each breath will naturally be reduced. In walking meditation, I notice I usually breathe in for four steps and breathe out for six. But when I climb, I do two steps for each in-breath and three for each out-breath. When it is very steep, I sometimes do one step for every breath in and, three, two, or one for every breath out. We have to adapt . Listening to your body as you walk will help make every step pleasant.

Day 3 - Intention

Walking meditation is a way to practice moving without a goal or intention. Mindful walking simply means walking while being aware of each step and our breathing. We can even practice mindful breathing and walking meditation in between business appointments or in the parking lot of the supermarket. We can keep our steps slow, relaxed, and calm. There's no rush, no place to get to, no hurry. Mindful walking can release our sorrows and our worries and help bring peace into body and mind.

Day 4 - Whole Body, Whole Mind

Don't pretend you're walking mindfully when in reality you're planning your grocery shopping or your next meeting. Walk with your whole body and mind. Each step contains insight. Each step has happiness. Each step has love - love and compassion for the Earth and for all beings, as

well as ourselves. Why do we walk like that? To be in touch with the great Earth, to be in touch with the world around us. When we're in touch, when we're fully aware of the wonder of walking on the Earth, each step nourishes and heals us. Thirty steps taken with this kind of insight are thirty opportunities to nourish and heal ourselves.

Day 5 - Slow Walking

When you are alone, you can practice slow walking meditation. Choose a distance of three meters, or ten feet, and as you traverse that distance, take one step for each in-breath and one step for each out-breath. With the first step you can say silently, "I have arrived." With the next step, you can say silently, "I am home". If you aren't arriving one hundred percent in the here and now, stay there, and don't make another step. Challenge yourself. Breathe in and out until you feel you have arrived one hundred percent in the here and now. Then smile a smile of victory. Then make a second step. This is to learn a new habit, the habit of living in the present moment.

Week Five - Mindful Sitting

Day 1 - Enjoy Your Breathing

When you sit down, the first thing to do is to become aware of your breathing. Becoming aware of your breathing is the first step in taking care of yourself. Becoming aware of your in-breath and out-breath, you can see how your breath moves through your body. You begin to take care of your body and your mind, and you begin to find joy in the very simple act of breathing. Every in-breath can bring joy; every out-breath can bring calm and relaxation. This is a good enough reason to sit. We don't need to sit with an intention like getting smarter or becoming enlightened. We can sit just to enjoy sitting.

Day 2 - Following Our Breath

Mindfulness is always mindfulness *of something*. When we are mindful, we are paying attention, but what are we paying attention to? Mindfulness always has an object. When we sit, we can become aware of our in-breath and out-breath. Follow your breath from the beginning of each inhale all the way through the end of each exhale. This is mindfulness of breathing. Each time we practice mindful breathing, we know a little more what mindfulness feels like.

Day 3 - Why sit?

When we sit, we bring joy and nourishment to ourselves and to others. Every time we sit, we can sit in such a way that the world can profit from our sitting. We are solid. We are relaxed. We are calm. We are happy while sitting. We can sit as if we are sitting on a lotus flower, not on a heap of burning charcoal.

Day 4 - The Non-Practice Practice

There are some people who sit in a very funny way; they try to show that they are practicing sitting meditation. When you breath in mindfully and joyfully, don't try to show off to other people as if you were saying, "You know, I am breathing in mindfully." Don't worry what your sitting looks like from the outside. Practice the non-practice practice. We can best convey the essence of the practice to others simply by doing it with our whole being.

Day 5 - Arriving Home

When you sit, sit in such a way that you feel you have already arrived. To sit doesn't mean to struggle. When you sit, sit so that sitting becomes an arrival into the present moment. Enjoy your arrival. How wonderful to have arrived. How wonderful to feel that you are home, your true home is in the here and the now. Sitting like that, joy and peace become a reality. You radiate this joy and peace and it benefits everyone around you.

Week Six - Mindful Compassion

Day 1 - The Practice of Metta

To love is, first of all, to accept ourselves as we actually are. The first practice of love is to know oneself. The Pali word *metta* means "loving kindness". When we practice Metta Meditation, we see the conditions that have caused us to be the way we are; it makes it easy for us to accept ourselves, including our suffering and our happiness. When we practice Metta Meditation, we touch our deepest aspirations. But the willingness and aspiration to love is not yet love. We have to look deeply, with all of our being, in order to understand the object of our meditation. The practice of love meditation is not autosuggestion. We have to look deeply at our body, feelings, perceptions, mental formations, and consciousness. We can observe how much peace, happiness, and lightness we already have. We can notice whether we are anxious about accidents or misfortunes, and how much anger, irritation, fear, anxiety, or worry are still in us. As we become aware of deep feelings in us, our self-understanding will deepen. We will see how our fears and lack of peace contribute to our unhappiness and we will see the value of loving ourselves and cultivating a heart of compassion. Love will enter our thoughts, words, and actions.

Day 2 - Loving Kindness

The essence of loving kindness is being able to offer happiness. You can be the sunshine for another person. You can't offer happiness until you have it for yourself. So build a home inside by accepting yourself and learning how to love and heal yourself. Learn how to practice mindfulness in such a way that you can create moments of happiness and joy for your own nourishment. Then you have something to offer the other person.

Day 3 - Immeasurable Minds

Loving kindness, compassion, joy, and equanimity are described as unlimited states of mind because they continue to grow and they cannot be measured. The more you practice, the more you see your love growing and growing until there is no limit. The more you practice compassion, the more it grows. The more you cultivate joy, the more joy you will feel and be

able to share. The more you understand, the more you love; the more you love, the more you understand. They are two sides of one reality. The mind of love and the mind of understanding are the same.

Day 4 - Attention

As long as we're rejecting ourselves and causing harm to our bodies and minds, there's no point in talking about loving and accepting others. With mindfulness, we can recognize our habitual ways of thinking and the contents of our thoughts. Sometimes our thoughts run around in circles and we're engulfed in distrust, pessimism, conflict, sorrow, or jealousy. This state of mind will naturally manifest in our words and actions and cause harm to us and to others. When we shed the light of mindfulness on our habitual thought patterns, we see them clearly. Recognizing our habits and smiling to them is the practice of appropriate mental attention, which helps us create new and more beneficial neural pathways.

Day 5 - Digging Deep

Practicing loving kindness meditation is like digging deep into the ground until we reach the purest water. We look deeply into ourselves until insight arises and our love flows to the surface. Joy and happiness radiates from our eyes, and everyone around us benefits from our smile and our presence. If we take good care of ourselves, we help everyone. We stop being a source of suffering to the world, and we become a reservoir of joy and freshness. Here and there are people who know how to take good care of themselves, who live joyfully and happily. They are our strongest support. Whatever they do, they do for everyone.

Week 7 - Mindful Relaxing

Day 1 -Relax

You don't need to set aside special time for resting and relaxing. You don't need a special pillow or any fancy equipment. You don't need a whole hour. In fact, now is a very good time to relax. You are probably breathing in and out right this moment. If you can close your eyes for a moment, do so. This will help you pay attention to your breath. Your body is doing so many things right now. Your heart is beating. Your lungs are inhaling and exhaling air. Blood is traveling through your veins. Without effort, your body is working and relaxed.

Day 2 - Awareness of Breathing

Your breathing is a stable, solid ground where you can take refuge. No matter what thoughts, emotions, and perceptions are going on inside you, your breath is always there, like a faithful friend. Whenever you're carried away by thinking, overwhelmed by strong emotions, or feeling restless and dispersed, return to your breathing. Bring body and mind together and anchor your mind. Become aware of the air coming in and going out of your body. With awareness of the breath, our breathing naturally becomes light, calm, and peaceful. At any time of the day or

night, whether you're walking, driving, working in the garden, or sitting at the computer, you can return to the peaceful refuge of your own breath.

Day 3 - Resting Poem

At any moment, we can say this small poem to ourselves and take a mini-rest. This poem is like a tiny vacation, except that it brings you back to your true home instead of taking you away from it.

Breathing in, I know I am breathing in.
Breathing out, I know I am breathing out.

You can even shorten this poem; it works just as well:

In.
Out.

Day 4 - Calm Waters

Each of us is like the waves and also like the water. Sometimes we're excited, noisy, and agitated like the waves. Sometimes we're tranquil like still water. When water is calm, it reflects the blue sky, the clouds, and the trees. Sometimes whether we're at home, work, or school we become tired, agitated, or unhappy and we need to transform into calm water. We already have calmness in us; we just need to know how to make it manifest.

Day 5 - Healing Energy

If you can sit in meditation on your own, quietly, and peacefully, that is already relaxing and healing. Even if nobody else knows you are meditating, the energy you produce is very beneficial for you and for the world. But if you sit with others, if you walk and work with others, the energy is amplified, and you can create a powerful collective energy of mindfulness for your own healing and the healing of the world. It's something one person cannot do alone. Don't deprive the world of this essential spiritual food.