MATH ANXIETY AND CONTEMPLATIVE PRACTICES

IN POST-SECONDARY CONTEXTS

by

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**MATH ANXIETY AND CONTEMPLATIVE PRACTICES IN POST-SECONDARY CONTEXTS**

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Abstract

Over fifty years ago, it was recognized that certain individuals became anxious when engaging in the practice of mathematics. Known as ‘math anxiety’, research indicates that:

1. Math anxiety affects math performance. The greater the anxiety, the lower the score in the math-related course.
2. Math anxiety leads to math avoidance. Students with math anxiety deny themselves a future in math-related careers, simply by avoiding subjects and jobs which use or include mathematics.

This study examined the impact of introducing contemplative practices to post-secondary students taking mandatory first year math courses. Using a case study, the goal was to investigate whether contemplative practices decreased math anxiety. The evidence-based contemplative practices were practiced over one semester, during math courses and as part of the participants’ personal practice. The triangulation of field notes, observations, a focus group discussion, and the semi-structured interviews identified the sources of self-perceived math anxiety and investigated the use of contemplative practices as viable interventions to reduce math anxiety. Results indicated that, within this local and place-based context, contemplative practices can be used by first-year math students to alleviate math anxiety and to support future coursework in mathematics or STEM-related fields to attain greater satisfaction and success in their lives.
Lay Summary

Over fifty years ago, it was recognized that certain individuals became emotionally disturbed in the presence of mathematics. This discomfort was later labeled ‘math anxiety’. Though much research has been performed since then, we are certain about two things:

1. Math anxiety affects math performance. The greater the anxiety, the lower the score in the math-related course.
2. Math anxiety leads to math avoidance. Students with math anxiety deny themselves a future in math-related careers, simply by avoiding subjects and jobs which use or include mathematics.

This research incorporates practices based on contemplation or introspection, such as meditation, visualization, journaling, and mindful activities, into the daily lives of post-secondary math students. The purpose of doing so is to investigate whether the practices decrease the amount of math anxiety felt by an individual, while taking a mandatory post-secondary math class.
Preface

The supervisor, committee members and the student worked in collaboration on this thesis.

Specifically,

- The design of this research program was co-devised by the student and the supervisor.
- The student performed the associated research and analysed the data.
- The manuscript was prepared by the student, edited by the supervisor and the committee members.
- This research required a harmonized ethics approval from two institutions:
  - UBC Okanagan Research Ethics Board, Certificate Number: H19-00463
  - Okanagan College Research Ethics Board, Reference Number: 19-016
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Dedication

To Marc from whom I first heard my chimes of freedom. Get bent *taxman*!

To Elizabeth who inspired me to be the best role model possible, and

To Brian for his support and his random conversations
Chapter 1: Introduction

1.1 Context and Background

In 2000, I began teaching post-secondary mathematics in the province of Manitoba, Canada. Like many of my post-secondary instructor peers, I had no pedagogical training. As a mathematician, I was hired for my content knowledge and to be able to teach higher level courses in mathematics and statistics so that students could achieve their career goals. The assumption was that I knew math; hence I should be able to teach it.

In 2005, I moved to the Okanagan region in another province in Canada, British Columbia, and continued to teach at the post-secondary level. I was thrilled to teach mandatory math courses for business, arts, and science students since I had enjoyed doing so in Manitoba. Suddenly, students commented on feeling stressed and anxious, often forgetting everything on test or exam day. Then, it came on quite quickly – the tears on test day, the upset stomachs, the nail biting. It was evident that the subject that I taught affected students emotionally and physiologically. Due to this reaction, I recognized that the courses I taught were not only a hurdle but a roadblock to completing a diploma, degree or attaining a desired career. I wanted my students to achieve their goals to successfully attain their careers of choice. I desired to help more than just the students who had the courage to come to see me. I asked myself how I could devise a program that could help students yet not require the time commitments that I had already undertaken – a program that other math educators could use to support more students. This question brought me back to university to begin a second master’s degree, this one in education.
1.2 Rationale

When a student walks into my classroom, I automatically believe that they will succeed. I have to since so many students enter my math class with negative baggage and lacking confidence. In *Overcoming Math Anxiety*, Tobias (1993) shared that the lack of mathematical ability prevents individuals from not only doing math, but from living their lives. Tobias (1986) wrote:

Ask anyone who ‘hates math’ to complete this sentence [If I could do math, I would…] and the first response will be incredulity. ‘What, me do math? Impossible.’… ‘If I could do math, I would…fix my own car… fly an airplane… (p. 33).

As these words attest to, it is easy to surmise that some individuals do not believe that they can do math. The literature demonstrates that this belief affects their course and career choices, preventing them from living up to their potential (Mighton, 2020; Choe, Jenifer, Rozek, Berman, & Beilock, 2019; Shishigu, 2018; Perry, 2004; Ashcraft, 2002; Tobias, 1993; Hembree, 1990).

Mathematicians have broached the subject of math illiteracy, coined ‘innumeracy’ by Paulos (1988), but have not delved into math anxiety per se. Their focus has been questioning the weak mathematical skills of students entering post-secondary and trying to understand the comfort of innumeracy. For example, statements such as “I’m a people person, not a numbers person” or “I’ve always hated math” (Paulos, 1988, p. 4) have become acceptable in society, though no one would boast in a similar manner of being illiterate. Also, Small (2016), a Canadian math education researcher, added that “mind-set is, for a kid, is (sic) influenced by their parents, and teachers have little control on that. So, if a kid comes to school and his mother
or father has already said, like, ‘I wasn’t any good in math,’ it’s really hard work for a teacher to undo that” (1:07).

Boaler, a renowned academic in math education from Stanford, stated that math educators needed to “stop giving the idea that only some students can learn math and some students can’t and replace that with the idea … that everybody’s brain can grow and change, and mistakes and challenge are the best ways to do that” (TEDx Talk, 2017b, 10:22). Boaler (2017) wrote about brain plasticity (or neuroplasticity); that is, the brain’s ability to “grow, adapt, and change” (p. 10) and based on that mindset stated that anyone can do math. Mighton, a Canadian mathematician working with math literacy, wrote that math “can be reduced to simple, logical steps that are accessible to any brain” (Mighton, 2020, p. 28-29). Between the two, clearly there is consideration that math is possible for everyone.

One day, after watching Boaler (TEDx Talks, 2017b), I viewed Shapiro’s “What we practice grows stronger” (TEDx Talks, 2017a). I had already been working with mindfulness practices in my own life to manage graduate student stress, among other things. In that video, Shapiro also spoke about neuroplasticity. Linking the two fields of mindfulness and mathematics instantly occurred to me. Understanding that the brain can be trained to develop new habits, I became interested in studying contemplative practices, including mindfulness, and its applications to the post-secondary (Zajonc, 2014; Shapiro, Brown, & Astin, 2011) as well as to math anxiety (Bellinger, DeCaro & Ralston, 2015; Brunyé et al., 2013). Specifically, contemplative practices may help some students who experience math anxiety. The payoff of decreasing math anxiety is immense – prospectively increasing confidence and performance in mathematics and putting an end to avoiding math courses and math-related fields.
Kabat-Zinn’s (1994) definition of mindfulness – “paying attention in a particular way: on purpose, in the present moment, and non-judgementally” (p. 4) – resonated with me, especially when thinking about math anxiety in my classroom. For example, if a student could focus on the present moment, then they could potentially set their worrying aside and increase their cognitive abilities on the (math) task (Bellinger et al., 2015; Shapiro, Brown, & Astin, 2011; Ashcraft & Kirk, 2001). If a student paid attention, on purpose, they could recognize when their anxiety was increasing and might be able to pause and give themselves time to respond instead of reacting (“smartEducation Facilitator Manual”, 2015; Shapiro et al., 2011).

Since I wanted to alleviate the high levels of math anxiety in my first-year courses, I decided to pursue my graduate work in this direction: exploring the impact of contemplative practices on anxiety in first-year mandatory math courses.

1.3 Significance

According to Beilock (2020), “93% of Americans report experiencing some level of math anxiety”; furthermore, “a 2016 study found that 11% of university students exhibited high enough levels of mathematics anxiety to be in need of counseling” (para. 22). Academics in education and psychology have been the primary investigators into math anxiety since it became a topic of study in 1957, initiated by Dreger and Aiken. Much research has been done since that time and two consequences of math anxiety have surfaced:

1. Math anxiety affects math performance. The greater the anxiety, the lower the score in the math-related course (Choe et al., 2019; Namkung et al., 2019; Shishigu, 2018; Chang & Beilock, 2016; Ma, 1999; Hembree, 1990).

2. Math anxiety leads to math avoidance. Hence, students deny themselves a future in Science, Technology, Engineering, and Mathematics (STEM)-related careers, simply by
avoiding subjects and jobs which include mathematics (Choe et al., 2019; Shishigu, 2018; Perry, 2004; Ashcraft, 2002; Tobias, 1993; Hembree, 1990), depleting the country’s scientifically-skilled workforce (Choe et al., 2019; Hembree, 1990).

My research fills a gap in the literature because I am examining the impact of contemplative practices on math anxiety at the post-secondary level. My double perspectives as a mathematician and as a graduate student in education exemplify the inherent connections between mathematicians, math teachers, and academics in mathematics education. Having these double roles is not a common phenomenon, though Sinclair (2017) and Noddings (2005) had beginnings resembling mine, with master’s degrees in mathematics before pursuing graduate degrees in education. To truly improve the state of math anxiety, all math educators need to work together. Bass (2005) elaborated on the strained relationship between mathematicians and academics in mathematics education with the following statements:

1. “it is a common belief among mathematicians that attention to education is a kind of pasturage for mathematicians in scientific decline” and
2. “many educators have questioned the relevance of contributions made by research mathematicians, whose experience and knowledge are so remote from the concerns and realities of school mathematics education” (emphasis in original, p. 418).

These two statements from Bass (2005) offer insight into “the conflicts between mathematicians and educators over the content, goals, and pedagogy of the curriculum” (p. 417). Perhaps, my research and shared perspectives can help to bridge these gaps.

The significance of this research will be multifaceted. The first and obvious result would be to potentially provide students with strategies focused on how to manage math anxiety. Secondly, since little has been written about contemplative practices and math in first year post-
secondary courses, this research would add to the body of knowledge for other researchers and educators. Most importantly, this study may provide students with the necessary confidence to pursue courses in mathematics or STEM-related fields to attain greater satisfaction and success in their lives. After all, as Mighton (2020) wrote, “everyone should have the right to fulfill their intellectual potential” (p. 31).

1.4 Research Question

Based on my own experiences as a mathematician and a graduate student in education, this thesis will explore the following question:

Do contemplative practices decrease perceived math anxiety at the post-secondary level?

To answer this question, a literature review related to math anxiety, contemplative practices and the intersection between these two concepts is included in the next chapter. As a follow-up to the literature review, the methodology chapter will describe the research design and the data collection. To conclude, an analysis and discussion will highlight the findings of this research, comment on the limitations and include future directions for this study.

To ensure clarity and shared understandings, key concepts have been defined below. These concepts will be used throughout the thesis and will provide seminal direction in guiding the research process.

1.5 Definition of Key Words

Throughout this thesis, the terms ‘math’ and ‘mathematics’ will be used interchangeably. The latter is used in more formal contexts while the former will be used in conjunction with anxiety as much as possible as it is both shorter and friendlier.
Math anxiety “refers to feelings of tension, fear, and physiological reaction and self-deprecatory thoughts and worries about one’s performance that interfere with solving mathematics problems in ordinary life and academic situations” (Ho et al., 2000; Richardson & Suinn, 1972; Wigfield & Meece, 1988, cited in Namkung, Peng & Lin, 2019, p. 460).

Self-report means “to give details about something yourself, rather than having them reported by someone else” (Cambridge Dictionary, n.d.).

Throughout this thesis, I will use the expression ‘mathematics educator’ to encompass all those who teach mathematics to other individuals. It includes:

- **mathematicians** – individuals with graduate degrees in mathematics, many whose main focus is on research;
- **math teachers** – individuals who teach children in Kindergarten through grade 12 who have at least a bachelor’s degree in education;
- **academics in mathematics education** – individuals with graduate degrees in education whose focus is on preparing future Kindergarten to grade 12 math teachers.

Contemplative practices are exercises based on contemplation or introspection, which include a wide variety of techniques such as mindfulness practices. Examining Figure 1 (see next page), the richness of practices from which one may choose are displayed.
Figure 1: The Tree of Contemplative Practices

(Used with permission, http://www.contemplativemind.org/practices)
Chapter 2: Literature Review

The literature review presented in this chapter provides an overview of the content used to answer the research question:

**Do contemplative practices decrease perceived math anxiety at the post-secondary level?**

Literature relating to math anxiety, contemplative practices, the commodification of mindfulness, and the intersection of math anxiety and contemplative practices are discussed.

### 2.1 Mathematics Anxiety

Mathematics (math) anxiety has been present in academic literature since 1957. At that time, Dreger and Aiken (1957) introduced the concept of ‘number anxiety’, applicable to individuals who were “emotionally disturbed in the presence of mathematics” (p. 344). In their study, they examined 704 college students and determined that:

1. Number anxiety differed from general anxiety.
2. Number anxiety and level of intelligence were not correlated.
3. Students with high number anxiety performed worse in math.

This study was groundbreaking in identifying a new field of study, one which examined math anxiety as well as its repercussions.

As indicated, I position myself first and foremost as a mathematician, then secondly as a graduate student in education investigating math anxiety. This positionality is in stark contrast to the many academics in mathematics education and in psychology who have studied math anxiety so far. For example, academics in mathematics education include Namkung, Peng, & Lin (2019), Shishigu (2018), Choe, Jenifer, Rozek, Berman, & Beilock (2016), Ma (1999) and Hembree (1990). Academics in psychology include Bellinger, DeCaro, & Ralston (2015), Brunyé et al. (2013), Ashcraft (2002), Ashcraft & Kirk (2001). Of these two types of investigators, neither is a
mathematician; that is, an academic with content-based expertise in a selection from a wide range of fields, such as algebra, analysis, dynamical systems, number theory, and logic. After teaching math at the post-secondary level for twenty years as well as completing my master’s coursework in education, I have acquired a pedagogical perspective to math anxiety. As a mathematician, I have the added lens emanating from deep mathematical learning, allowing me to see connections and relationships from early math content to post-secondary concepts.

In my extensive research, Perry (2004) was found to be one of the only mathematics professors who investigated math anxiety at the post-secondary level. However, his work was both ambiguous and anecdotal. Other than stating that he administered “surveys” to his students during the first week of the semester in “introductory mathematics classes”, very few details were provided. Further, the questions contained in the surveys or the type of introductory class – arts, business, sciences, technologies – are not specified.

Despite the lack of a rigorous method in examining math anxiety, Perry (2004) concluded that, instead of blaming others, “students must direct their energies towards improving their mathematical abilities and solving problems” (p. 323). He surmised that a positive attitude, including seeking help, were enough to improve mathematical ability and decrease math anxiety.

Ashcraft and Kirk (2001) “found substantial evidence for performance differences as a function of math anxiety” (p. 224). In certain cases, they found that “high-anxiety participants are simply less competent in math, unable to perform the necessary calculations at the same level of accuracy as low-anxiety individuals” (p. 224), a statement which aligns with Perry’s (2004) suggestion of simply improving math skills to decrease math anxiety. They also replicated many of the math anxiety effects shared by Hembree (1990), such as math avoidance and the decrease
in math performance, stating that “high math-anxiety individuals enroll in fewer math courses and earn lower grades in the math classes they do take” (p. 225).

Ashcraft and Kirk (2001) also examined, using surveys and math tasks in a laboratory setting, the relationship between math anxiety and working memory capacity, where working memory “governs not only storage and retrieval functions involving long-term memory but also planning and decision-making processes” (Hopko, Ashcraft, Gute, Ruggiero & Lewis, 1998, pp. 344-345). Ashcraft and Kirk (2001) determined that there was a negative association between the two in tasks involving arithmetic or algorithms. That is, the greater the math anxiety, the smaller the working-memory capacity to put toward mathematical tasks, which may partially explain the low performance issues.

Ashcraft and Kirk (2001) suspected that math-anxious individuals did less math homework because of a lack of confidence and a history of avoiding math, resulting in insufficient practice. Without the necessary practice to develop mathematical skills, math anxious students were less competent in performing mathematical tasks.

Individuals who have positive attitudes toward math, along with low math anxiety, tend to naturally include math in their lives. In consequence, they improve their competence and activate their skills, leading to better performance results (Ashcraft & Kirk, 2001). “In the reverse situation, with poor attitudes and high math anxiety, individuals exhibit global avoidance and attain lower competence, again with obvious effects on performance” (p. 236).

According to Ashcraft (2002), “Perhaps the most pervasive—and unfortunate—tendency is avoidance. Highly math anxious individuals avoid math. They take fewer elective math courses, both in high school and in college, than people with low math anxiety. And when they take math, they receive lower grades” (p. 181).
Individuals with high math anxiety tend to adopt negative attitudes about math and often have negative perceptions of their own math abilities (Ashcraft, 2002). Ashcraft elaborated on how some of the students’ math-avoidance was related to instructor behaviours, such as “a high demand for correctness but provide[d] little cognitive or motivational support during lessons” (p. 101), showing “annoyance when students gave wrong answers” or holding students “responsible for their lack of understanding” (p. 102). Ashcraft (2002) shared that “public embarrassment in math class contributed to their [students’] math anxiety” (p. 185). According to Shishigu (2018), “teaching strategies involving independent and competitive mathematics activities” (p. 7) also contribute to math anxiety. Hence, the classroom environment, including instructor behaviours and teaching methods, influence math anxiety.

Influences from students, parents and teachers are factors that Chang and Beilock (2016) considered in their investigations into math anxiety. Instead of focusing solely on the performance of one individual, Chang and Beilock (2016) examined the influence of other students, parents and teachers, stating that “teachers’ math anxiety and classroom activities, parental math anxiety, support and expectations, and students’ perceived classroom environment are non-negligible social or contextual factors that may affect the math anxiety-math performance relation” (pp. 35-36).

Jay, Rose, and Simmons (2018) stated that “parents and the home environment are generally recognized as making a substantial contribution to children’s mathematics learning” (p. 2). Small (2015), a Canadian math education researcher, added that “the anxiety really comes from the adults around them [the students], whether the adult is their mother, their father or someone else in their family or whether it’s the teacher” (0:00). Furthermore, according to
Hembree (1990), “the highest levels [of math anxiety] occurred for teacher candidates preparing
to teach in elementary school” (p. 42). Paulos (2001) wrote that

Some of the blame for the generally poor instruction in elementary schools must
ultimately lie with teachers who aren’t sufficiently capable, and who too often
have little interest in or appreciation of mathematics. (p. 102)

Beilock, Gunderson, Ramirez, and Levine (2009) added that “students can successfully pursue a
career as an elementary school teacher even if they have a propensity to avoid math” (p. 1860).
Not only are “elementary education majors largely female and have the highest levels of math
anxiety of any college major” (p. 1860), their math anxiety influences the math performance of
girls in their class.

Unfortunately, there are not only many influences on math anxiety, but also many
consequences to math anxiety. The following three meta-analyses will consider various
consequences, starting with the correlation between math anxiety and math performance. All
three meta-analyses focused on a large number of studies and were based on quantitative
analysis. They will be referenced in chronological order, from Hembree (1990), to Ma (1999), to
Namkung, Peng, & Lin (2019).

The first meta-analysis, effectuated by Hembree (1990), is the most salient for this
research since it investigated 122 out of 151 studies at the post-secondary level. Hembree (1990)
expressed the importance of evaluating math anxiety, since “when otherwise capable students
avoid the study of mathematics, their options regarding careers are reduced, eroding the
country’s resource base in science and technology” (p. 34).

Via his meta-analysis, Hembree (1990) investigated and confirmed six hypotheses:

1. The inverse relationship between positive math attitude and avoidance. That is, the more
positive the attitude, the less likely the avoidance.
2. The imperfect correlation between test anxiety and math anxiety. Throughout his analysis, he concluded that “like test anxiety, mathematics anxiety seems to be a learned condition more behavioral than cognitive in nature” (p. 45). Statistically speaking, out of the 151 studies, Hembree (1990) determined that the sample correlation coefficient (Moore, McCabe & Craig, 2017, p. 101) between math anxiety and test anxiety was significant with a value of \( r = 0.52 \), demonstrating a positive correlation between the two. That is, the greater the math anxiety, the greater the test anxiety, and vice-versa. The coefficient of determination (the r-squared value) is 0.37, meaning that only 37% of the variance of math anxiety is explained by test anxiety. The remaining 63% of the variation is explained by other factors, which were not specified.

3. Hembree (1990) confirmed Tobias’ (1985) skills-deficit model linking the lower scores of test-anxious students to poor study habits and/or deficient test-taking skills.

4. The negative correlation between math anxiety and math performance. The greater the anxiety, the lower the math score. At the post-secondary level (based on the 122 studies), Hembree (1990) determined that the sample correlation coefficient (also significant) was \( r = -0.27 \). Based on his calculations, only 7% of math performance is directly explained by math anxiety. The remaining 93% is explained by other factors, such as a lack of mathematical mastery or deficient mathematical skills (Perry, 2004; Ashcraft & Kirk, 2001; Tobias, 1985), cognitive processes being overtaken by ruminations (Ashcraft, 2002) or teacher, parental or peer influences (Shishigu, 2018; Choe, Jenifer, Rozek, Berman, & Beilock, 2016; Ashcraft, 2002).

5. Students with high levels of math anxiety saw a decrease in their anxiety levels with further math study.
6. Effects of interventions: Hembree (1990) included different interventions performed on a classroom-wide scale as well as ones performed on individuals. According to his analyses of surveys and assessment tests, the most effective treatments were behavioral ones used along with anxiety management and relaxation training. He did not find that class-wide interventions, such as curriculum changes, to be successful.

The next, yet less applicable, meta-analysis was performed by Ma (1999), included 26 studies and only considered students from grades 5 through 12 (not the post-secondary). Not only was Ma investigating the negative relationship between math anxiety and math performance, he also considered the effect attributed to grade school levels, gender, and ethnicity. His research findings on the latter demonstrated no significant differences in any of those categories.

The Ma (1999) sample correlation coefficient, again measuring the association between math anxiety and math performance (this time, at the grade school level), was also determined to be significant, with a value of $r = -0.27$. This value matches the value determined by Hembree (1990) at the post-secondary level. Ma’s (1999) meta-analysis supported the introduction of coping techniques, such as “psychological treatments, systematic desensitization and anxiety management” (p. 532) as ways to decrease math anxiety. Ma’s findings also supported the claim that previous poor math performance increases math anxiety. Further, the author determined a noticeable improvement in math performance when a highly math anxious student decreased their anxiety.

The last of the meta-analyses, Namkung et al. (2019), also examined the correlation between math anxiety and math performance, with a focus on school-aged children. They posited and demonstrated numerically that a moderate negative correlation exists between math anxiety
and math performance via a meta-analysis of 131 studies, a correlation supported by the two
previously discussed meta-analyses (Ma, 1999; Hembree, 1990). Their calculated sample
correlation coefficient was $r = -0.34$, leading to 11.5% of math performance explained by
anxiety.

Based on their analyses, Namkung et al. (2019) confirmed that
1. Math anxiety leads to math avoidance (Choe et al., 2019; Shishigu, 2018; Perry,
   2004; Ashcraft, 2002; Tobias (1993); Hembree, 1990).
3. Poor math performance leads to higher math anxiety (Choe et al., 2019; Ma, 1999).
4. The younger the student, the less anxious they are. In fact, Namkung et al. (2019)
   postulated that math anxiety generally begins around grade 4 and increased with the
   grade level, as more negative experiences and more challenging mathematics are
   encountered. This theory demonstrated that younger students generally have less
   math anxiety than older ones. Namkung et al. (2019) added that “even simply
   numerical tasks, such as counting, can also elicit MA [math anxiety] among adults”
   (p. 463).
5. A correlation between math anxiety and test anxiety exists (Hembree, 1990).

These three meta-analyses emphasize the challenges brought on by math anxiety,
reinforcing the need to address this concern. All three studies conclude that math anxiety affects
performance in mathematics. Hembree (1990) and Namkung et al. (2019) agree with Ashcraft
(2002) that math avoidance is linked to math anxiety. Choe et al. (2019) are in line with previous
statements, in particular how high math-anxious individuals avoid math, including taking less
math-content courses and avoid Science, Technology, Engineering, and Mathematics (STEM)
careers more often than those with lower math anxiety. According to Choe et al. (2019), math anxiety and math avoidance lead to lower math competency as well as lower math performance, which leads to further math anxiety and avoidance. Hence, the authors posited that the behaviour is cyclical in nature.

Shishigu (2018) studied math anxiety in 370 randomly selected grade 9 students from five different secondary schools, where 184 were male and 186 were female. All participants took a modified 22-item Math Anxiety Rating Scale (MARS) questionnaire. It is of note that a variety of MARS assessments are currently in use on a global scale. The MARS used in Shishigu’s (2018) study is most likely the version created by Beasley, Long & Natali (2001).

Prior math performance was calculated based on the midterm and the final exam from their first semester as grade 9 students along with their score from their grade 8 national exam. Using statistical analysis, Shishigu (2018) confirmed many of the previously stated hypotheses emanating from the meta-analyses and examined the effects of prior math performance. He linked prior math performance with both math anxiety and current math performance, stating that “prior math achievement was also the strongest predictor of math anxiety” (p. 7), demonstrating that previous experiences affect current math performance and math anxiety. That is, prior positive math performance led to decreased math anxiety and improved current math performance, while prior negative math performance did the reverse – increase math anxiety and decrease math performance.

Choe et al. (2019) created the “first experimental demonstration of a direct relationship between math anxiety and avoidance, controlling for math ability and other confounds” (p. 1), by measuring effort-avoidance in both math and non-math subjects. The authors “hypothesize[d] that math avoidance is related to individuals’ perceptions of the costs and benefits associated
with effortful math engagement and that this perception depends on individual differences in math anxiety” (Choe et al., 2019, p. 1). They measured the level of effort when avoiding a math or non-math task based on financial gains. That is, participants were paid more money based on the complexity of the problem, whether math or non-math. The researchers concluded that students avoided the more demanding math questions despite the larger payout.

Choe et al. (2019) determined that math anxiety is enough to lead to avoidance even when the financial reward is high “because they perceive the costs of effortful math engagement to outweigh its benefits” (p. 5). They also examined fMRI data and determined that math anxiety actually “activates the pain network in anticipation of doing math and the fear network while either performing math or simply viewing mathematical symbols for a brief period” (p. 5). This research suggests that math anxiety is very real and that individuals feel physical pain and experience real fear when performing mathematical operations.

The meta-analyses and the research presented in this chapter examined possible causes and consequences of math anxiety. Shishigu (2018), Chang and Beilock (2016) and Ashcraft (2002) determined that the classroom environment and instructor behaviours directly affect math anxiety levels. Chang and Beilock (2016) added that peers and parents also have a role in math anxiety levels. Ashcraft (2002) established the link between math anxiety and the use of cognitive resources. The negative correlation between math anxiety and math performance was examined and confirmed in all three meta-analyses (Namkung et al., 2019; Ma, 1999; Hembree, 1990). Choe et al. (2019), Perry (2004), Ashcraft and Kirk (2001), and Hembree (1990) all concluded that math anxiety leads to math avoidance which in turn decreases math competency, diminishes math performance and affects course and career choices of math-anxious students.
The research undertaken in this thesis fills a recent gap in the literature since it considers math anxiety at the post-secondary level in 2019. Hembree’s (1990) meta-analysis was the most pertinent with a primary focus on post-secondary studies (122 out of 151) yet was performed nearly thirty years ago.

According to Hembree’s (1990) analysis, the most effective treatments were behavioral ones used along with anxiety management and relaxation training. The next section will discuss evidence-based techniques promoting anxiety and stress regulation as well as fostering relaxation.

2.2 Contemplative Practices

The above section provided an overview of the literature regarding math anxiety and its repercussions in the development of math avoidance, math skills and math performance. The next section of this chapter will focus on contemplative practices in the post-secondary as an intervention to support stress management and resiliency in anxiety-fueled learning contexts.

As detailed in the Introduction, contemplative practices are exercises based on contemplation or introspection, which include a wide variety of techniques, including meditation, visualization, yoga, journaling, and mindful activities (cf. Figure 1, The Tree of Contemplative Practices). “Contemplative practices can help develop greater empathy and communication skills, improve focus and attention, reduce stress and enhance creativity, supporting a loving and compassionate approach to life” (Center for contemplative mind in society, n.d., para. 2).

In 1979, Kabat-Zinn, a molecular biologist from Massachusetts Institute of Technology, secularized Buddhist practices to assist cancer patients who were not responding to regular pain management treatment and in turn developed a program later called Mindfulness-Based Stress
Reduction (MBSR). Kabat-Zinn (1994) defines mindfulness as “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally” (p. 4).

Contemplative practices, like mindfulness, are used in various settings and at a variety of levels to prospectively help lower anxiety or stress levels. Even when used for short periods of time, contemplative practices have been proven to improve attention and cognition (Zajonc, 2014; Brunyé et al., 2013). According to Zajonc (2014), “nearly every area of higher and professional education is now being taught with contemplative exercise for the training of attention … for stress reduction… for general capacity building” (p. 22).

Shapiro, Brown, & Astin (2011) have extensively studied MBSR programs in higher education and their effects on stress. Moreover, smartEducation (“smartEducation Facilitator Manual”, 2015), a twenty-hour derivative of MBSR, is an evidenced-based program which “reduces stress and promotes emotional resilience in teachers” (Ragoonaden, 2017, p. 243). Knowing that MBSR-types of programs may benefit the classroom, the remaining question related to implementation. Burack (2014) answered the question with his framework which incorporates contemplative practices in the classroom. The four pillars of his framework are:

1. The benefits of contemplative practices and simple ways to introduce them in a classroom: One such strategy includes reflecting on the syllabus, on the first day of classes. This reflection allows students to ponder what they want/expect from the course in groups and can encourage collaboration or the building of peer relationships. The introduction of mindful listening and speaking can be done here and set the stage for a more welcoming and more comfortable classroom environment.
2. The well-being of students: Burack (2014) prompted educators to *invite* students to participate in contemplative practices, not to tell them. Also, it is important to remind students to stop if they feel uncomfortable, to “stop doing the contemplation if you experience discomfort or agitation that you feel you can’t handle—and immediately open your eyes” (p. 43).

3. The requirements for the instructor relating to experience, knowledge, and skill: Burack (2014) stated that “the best preparation for leading contemplation is having one’s own contemplative practice and being committed to one’s own holistic growth and transformation” (p. 45).

4. The separation of church and state: Since most post-secondary institutions are public and not affiliated with any particular religion, it is important not to impose religious beliefs on anyone, in particular, vulnerable students. Since mindfulness evolved from the secularization of Buddhist techniques, the removal of any religious spirituality from the practices and the language used is mandatory. Doing so carefully may also remove the fear that mindfulness is simply a means to expose susceptible students to Buddhism (Hyland, 2016).

Berila (2014) also focused on educating the whole student, since it included both the inner and the outer life of an individual. Berila (2014) warned about being proactive when incorporating contemplative practices into a classroom. For example, she shared the importance of preparing for negative reactions during practices – to plan and to expect, instead of being surprised. In the end, Berila (2014) posited that contemplative techniques could assist with courses that deal with oppression (including mathematical oppression, where there are conditioned responses, fear, anxiety, low self-confidence, or self-deprecating attitudes) and with
marginalized students. She further impressed the need to “give the students a language with which to make sense of the overwhelming feelings that might arise” (p. 61).

Contemplative practices, including mindfulness, are used in diverse settings and at a variety of academic levels. Shapiro et al. (2011) suggested that “mindfulness-based training may enhance students’ capacities to tolerate the stresses of higher education, reflected in self-reported decreases in stress, negative emotions, and other psychological symptoms” (p. 505). Shapiro, Brown, Thoresen, & Plante (2011) extensively studied MBSR programs in higher education and presented declines in perceived stress as well as state and trait anxiety.

The Shapiro, Brown, and Astin (2011) review began by comparing different forms of meditation along with the benefits of each, then dove into empirical evidence. They listed the effects of meditation on “cognitive and academic performance, management of academic-related stress, and on the development of the whole person” (p. 501). Though all the discussed effects are backed by scientific experiments and empirical evidence was shared, the main interest to this thesis is the middle hypothesis, the one relating to mental health and well-being. “The stresses of higher education have been related to numerous mental and physical health problems … and may adversely affect academic and cognitive performance” (p. 506). While certain amounts or types of stress may improve performance (Shapiro et al., 2011; TEDGlobal 2013, 2013), others may be detrimental.

Similar to findings of Ashcraft and Kirk (2001) on the relationship of math anxiety and working memory capacity, Shapiro et al. (2011) exposed the relationship between stress and memory impairment, affecting learning. Their review considered forty years of research which demonstrated that meditation “reduces negative mental health symptoms, including stress and

Shapiro, Schwartz, and Bonner (1998) conducted research which examined the benefits of meditation via a MBSR course offered to medical students. “Results indicated decreased levels of anxiety and depression in the MBSR group as compared to the wait-list control group” (Shapiro et al., 2011, p. 15). It is important to keep in mind that MBSR is a longer-term intervention, requiring eight or more weeks of practice and attendance. Similarly to Zajonc (2014), the authors posited that post-secondary students may also benefit from shorter-term interventions, also supported by Brunyé et al. (2013).

Over forty years of research have supported the benefits of MBSR-type of programs (Chin et al., 2019; Ragoonaden, 2017; Zajonc, 2014, 2013; Shapiro et al., 2011). Since its inception in 1979 by Kabat-Zinn, mindfulness became a new field of study, extending from pain management to coping with stress and creating resilience (Shapiro et al., 2011; Ragoonaden, 2017) in a wide range of contexts, spilling into mainstream culture and beginning to be used as a solution to a wide variety of mental health problems.

2.3 Commodification of Mindfulness

Van Dam et al. (2017) stated that “in the early 2000s, mindfulness saw an exponential growth trajectory that continues to this very day” (p. 2). According to Hyland (2016), “there is a sense in which the short-term commercialized mindfulness strategies can be seen as a quick fix, or a band-aid, or a panacea for all the current ills and anguish of contemporary life” (p. 111). Hence, without moral foundations, mindfulness risks simply being another self-help fad (Hyland, 2017). Safran (2014) defined McMindfulness as the “marketing of mindfulness practice as a commodity that is sold like any other commodity in our brand culture” (p. 1).
Adoption by corporate entities “clearly raises issues about the misuse and, in some cases, outright abuse of MBIs [Mindfulness Based Interventions] since foundational mindfulness values such as right livelihood, loving-kindness, compassion and non-materialism are self-evidently and fundamentally at odds with aspects of the core business of corporations and the military” (Hyland, 2015, p. 181).

Forbes (2012) posited that mindfulness practices might be used by schools to increase test scores, reinforce student conformity and empower those at the top:

Rather than valuing the intrinsic experience that mindfulness embraces—curiosity, creativity, pondering, wondering, exploring, not knowing, cherishing openness, a sense of awe without presupposing or seeking correct results and predetermine answers—education instead values the production of successful outcomes such as test scores. (Forbes, 2012, para. 23)

As we have seen, Kabat-Zinn (1994) defined mindfulness as “paying attention in a particular way: on purpose, in the present moment and non-judgmentally” (p. 4). Van Dam et al. (2017) stated that the ambiguity in mindfulness definitions, the interchanged use of ‘meditation’ and ‘mindfulness’ as well as questionable methodology causes confusion in the public as well as feeds the hype of mindfulness. “At a practical level, the misinformation and propagation of poor research methodology can potentially lead to people being harmed, cheated, disappointed and/or disaffected” (pp. 2-3).

Hyland (2016) reminded us that mindfulness is a journey – a long-term mindset – not simply a goal or a destination. Yet, many entities, including school administrations, use mindfulness as a means to an end. Many academic institutions have “expropriated” mindfulness interventions only to create another academic subject or field of study and quantify it by using various mindfulness scales. Finally, Hyland (2016) added the fact that the commodification of mindfulness exemplifies short-term, quick fixes; instead, of the proven benefits of long-term,
sustained practice shared by Shapiro (TEDx Talks, 2017a) in her talk entitled “What we practice grows stronger”.

Despite its ever-growing popularity and mounting evidence of its benefits, contemporary mindfulness practices are not without its critics, especially surrounding the commercialism of mindfulness and its prospective overuse or misuse. Nonetheless, the literature indicates that mindfulness offers a refuge from stress and pain as well as a powerful set of skills and practices to navigate our lives. That is why the next section explores the intersection of math anxiety and contemplative practices in a thoughtful and constructive manner.

2.4 Intersection of Math Anxiety and Contemplative Practices

Let us now consider the intersection of contemplative practices and math anxiety at the post-secondary level. Brunyé et al. (2013) investigated four interventions that could assist in the regulation of negative emotions accompanying math anxiety. Brunyé et al. (2013) confirmed what Ashcraft and Kirk (2001) previously stated: students with high math anxiety waste cognitive resources on worrying, rather than on the math task at hand, affecting overall performance. Hence, mindfulness techniques which encourage focusing on the present moment instead of ruminations can prove to be helpful.

Brunyé et al. (2013) admitted that longer-term courses, such as MBSR and smartEducation, improved cognition and helped to regulate emotions, supported by Shapiro et al. (2011) and Ragoonaden (2017). Brunyé et al. (2013), however, wanted to determine whether short-term practices could also have positive effects on math anxiety. The primary focus of their study was to reduce math anxiety in an effort to remove the restriction on mental resources induced during high-pressure situations. Prior to writing a timed arithmetic test, post-secondary students participated in three behavioral interventions and one nutritional intervention. The goal
was to devise supports for students that required little time commitment and which were easy to implement.

The interventions were:

1. A focused breathing exercise (a guided exercise, based on a script from Kabat-Zinn, 1995);
2. An unfocused exercise, where students let their minds wander;
3. A ‘worry exercise’, where students were asked a list of anxiety-inducing questions;
4. The consumption of teas containing different levels of L-theanine.

This study was a longitudinal study across six sessions involving 36 participants. The participants needed to complete a number of self-reported questionnaires: one measuring their psychological state at four different moments during each session, two measuring their mindfulness levels – the Five Facets Mindfulness Questionnaire (FFMQ, see Appendix A) and the Mindfulness Attention Awareness Scale (MAAS, Brown & Ryan, 2003), one measuring their ability to “maintain information in working memory while also solving simple arithmetic tasks” (p. 3), and one measuring their math anxiety level (the Math Anxiety Rating Scale, MARS, Richardson & Suinn, 1972).

Brunyé et al. (2013) determined that a significant positive difference existed when highly math-anxious students participated in breathing exercises, particularly focused or guided ones. When compared to low math anxiety participants, highly math-anxious participants scored 14% lower on math tests. Participants who performed the focused breathing exercise right before the test increased their accuracy by 9% compared to those performing the worry exercise and 6% to those doing the unfocused breathing, narrowing the gap with those participants with lower math-anxiety.
The purpose of the focused breathing exercise was to decrease anxiety and to distract participants from their negative emotions relating to their math test. Though focused breathing did improve anxiety levels, it did not increase math performance enough to erase the difference between the high and the low anxiety groups, though, perhaps “longer-term mindfulness practices might prove effective in narrowing this gap” (p. 5).

Bellinger et al. (2015) undertook two different studies, evaluating the effects of mindfulness on working memory resources as well as math performance. As mentioned earlier, Shapiro et al. (2011) and Ashcraft and Kirk (2001) discussed the drop in working memory when anxious or stressed. According to Bellinger et al. (2015), “individuals who received mindfulness training, and extensively practiced, did not show this drop in working memory” (p. 124). They also elaborated that mindfulness’ benefits may also extend to stressful academic environments. Like Choe et al. (2019), Shishigu (2018), Perry (2004), and Ashcraft (2002), Bellinger et al. (2015) disclosed the effect of poor math performance leading to math avoidance. Bellinger et al. (2015) determined that mindfulness reduced anxiety associated with stressful testing conditions and improved accuracy of math problems requiring working memory. To conclude, the more mindful the student, the more likely the student may succeed in stressful testing situations.

Aware of emergent criticism regarding the commercialized perspective surrounding mindfulness, the research undertaken in this thesis incorporates the more general expression of ‘contemplative practices’ instead of ‘mindfulness practices.’ The practices chosen for this research are based on Berila (2014) and Burrack’s (2014) work with post-secondary students. Based on the above, results demonstrating the positive effects of mindfulness on working memory and math performance support future study in this area. The next section provides an overview of the mindfulness interventions and strategies used in the program created to support
this research called *Mindful Math* to decrease math anxiety in students enrolled in first-year mandatory college math courses.

### 2.5 *Mindful Math Sessions*

Six *Mindful Math* sessions, based on contemplative practices discussed in the previous section, were conceptualized and developed to in. The aim of the *Mindful Math* sessions was to observe the impact of contemplative practices on self-perceived anxiety of students enrolled in first-year math courses. The first three sessions occurred on a weekly basis, whereas the last three were offered biweekly to allow participants time to develop their own practice. The sessions also included discussions, videos and the completion of questionnaires. These sessions occurred outside the realm of classes and were positioned as a student support initiative.

In terms of their construction, the *Mindful Math* sessions followed suggestions from both Berila (2014) and Burack (2014). Berila’s advice to be proactive when incorporating contemplative practices into a classroom led to specific practices being chosen and others omitted. For a brief description of each of the following practices, the Pause practice, the raisin meditation, the sitting meditations, the math class visualization, the 5-4-3-2-1 practice and the Loving-Kindness practice, see Appendix D.

Session 1: The first session followed Burack’s (2014) structured framework. This session included a discussion about the benefits of contemplative practices including the secular nature of the practices, direction about how to introduce the practices, a focus on the well-being of students and an overview of the instructor experience and knowledge requirements. Afterwards, the raisin meditation (see Appendix D) was introduced to increase awareness and concentration (“smartEducation Facilitator Manual”, 2015; Zajonc, 2013). The technique of writing down anxieties instead of ruminating over them was shared to minimize the decrease in working
memory. As per Bellinger et al. (2015) and Ashcraft (2002), less time spent ruminating led to having more working memory for solving math problems or performing computations. Breath awareness and focused breathing were introduced during the first session to decrease anxiety (Brunyé et al., 2013). This session concluded with the pre-test of the FFMQ (see Appendix A), which measured mindfulness levels via a validated 39-item, self-reported questionnaire. As a self-reported mindfulness measure, students were required to take the same FFMQ as a post-test for comparison purposes at the end of the sessions.

Session 2: During the second session, the Pause practice (see Appendix D) was introduced. This practice focuses on three items – thoughts, emotions and physical sensations – to bring attention to the present moment (“smartEducation Facilitator Manual”, 2015). The difference between ‘doing’ and ‘being’ was explored, where ‘being’ was related to present-moment awareness versus ‘doing’ mode’s automation (“smartEducation Facilitator Manual”, 2015). The viewing of the video “How to make stress your friend” by Kelly McGonagall (TEDGlobal 2013, 2013) and an associated discussion relating to math-related stress demonstrated that stress need not always be negative. Participants were invited to be aware when math stress or anxiety occurred, to acknowledge it and to accept that it need not be negative. If they felt overwhelmed with stress or anxiety, they were invited to attempt a Pause practice.

Session 3: The third session began with the STOP practice to offer a different way to pause. STOP is short for: “S – Stop and take stock; T – Take a breath; O – Open and Observe; and P – Proceed/new possibilities” (Palouse Mindfulness, n.d.). Participants were invited to pause, using either the Pause or STOP practice during anxiety-increasing math-related activities and to pay attention and to try to identify the ensuing response on a physical, emotional, and intellectual level.
An extended visualization was also introduced to develop comfort and confidence in the math class environment (Gilbert & Gilbert, n.d.). The difference between meditation and visualization was presented (“smartEducation Facilitator Manual”, 2015). Participants were invited to practice the visualization, so that they could become more familiar and comfortable with the math classroom, thereby minimizing anxiety.

Session 4: The 5-4-3-2-1 practice (see Appendix D) was introduced in the fourth session, using senses to increase awareness of the present moment and foster mindfulness skills (Smith, 2018). We watched Shapiro’s “What we practice grows stronger” (TEDx Talks, 2017) to reinforce ideas discussed during the previous weeks. Due to the correlation between math anxiety and test anxiety (Namkung et al, 2019; Brunyé et al., 2013; Hembree, 1990), techniques related to test anxiety were discussed and explored (Gilbert & Gilbert, n.d.). Outside of previously discussed breathing techniques, we considered bringing an artefact or picture to a math test to assist with calm and/or visualization.

Session 5: The fifth session began with an extensive Pause practice, where we discussed the importance of pausing between when anxiety starts and when we react, allowing us to respond in a healthier way (“smartEducation Facilitator Manual”, 2015). We also discussed acknowledging the emotion and then letting it go (Palouse Mindfulness, 2018). We watched Kristen Neff’s “The Space between self-esteem and self-compassion” (TEDx Talks, 2013) and followed it with a Loving-Kindness practice, slightly modified to include pets (see Appendix D). The Loving-Kindness practice was used to cultivate self-compassion, to in turn reduce the self-judgement and the self-criticism that fueled some of the math anxiety within the participants.

Session 6: Chin et al. (2019) studied the role of acceptance in mindfulness courses via a randomized control trial. According to the authors, “acceptance is an emotion regulation skill
that fosters nonreactivity and openness to present moment experiences” (Chin et al., 2019, p. 760). They studied two groups – one which included acceptance and another which did not. They determined that participants had reduced stress as well as less frequent stressful episodes when incorporating acceptance and posited that acceptance had many benefits. Hence, the sixth session began with a visualization practice to improve acceptance, based on Chin et al. (2019)’s research, that all programs using mindfulness should have an acceptance component.

A letter writing exercise taken from Neff’s (2011) work in self-compassion was used. In this activity, participants were invited to list their self-criticisms. At a later date, they were invited to read the letter from the perspective of a beloved friend and to reply accordingly. Again, fostering self-compassion within the participants aimed to decrease the self-deprecating attitudes that accompanied the math anxiety.

The six Mindful Math sessions were delivered during September, October, and November 2019. The contemplative practices introduced in the sessions are evidence-based and were practiced during the sessions over the course of the semester, during math courses and as part of the participants’ personal practice. The next chapter provides a detailed description of the methodology and the measures used to answer the research question:

**Do contemplative practices decrease perceived math anxiety at the post-secondary level?**
Chapter 3: Methodology

A descriptive picture that relates directly to math anxiety at the post-secondary level has not been fully discussed, especially by a mathematician. Using a case study design, the question “Do contemplative practices decrease perceived math anxiety at the post-secondary level?” was investigated. The dataset is comprised of field notes, observations, a focus group discussion, individual semi-structured interviews, and completed questionnaires. Analysis of the qualitative data used thematic analysis to code and aggregate answers provided, while the data analysis of the questionnaires focused on descriptive statistics and was used to triangulate the coded themes. Details supporting each step of this process are presented in the following sections.

3.1 Research Design

In the social sciences and humanities, the case study has become a prolific research tool, offering an in-depth look at a group or a theory. It is an integrated system, with many working parts. The case study is more than purposeful – it is purposive. It is both a process of inquiry about the case as well as the product of that inquiry.

Yazan (2015) provided insight and differentiation on the case study as a research methodology, based on the three giants of case study design – Yin (2014), Merriam (1998) and Stake (1995). With other qualitative designs, Merriam and Tisdell (2016) wrote that case studies “search for meaning and understanding… the end product being richly descriptive” (p. 37). Stake (1995), Merriam (1998) and Yin (2014) all described the case study “as a bounded system, in which the researchers set out boundaries and make clear statements about the focus and extent of the research” (“Case study by P2YK”, 2016, para 6). My case is my research group, that is, the students who agreed to participate in the Mindful Math sessions. The parameters of the bounded system were defined by what we examined (contemplative practices and how it affected math
anxiety) and what we were not going to do (practice math problems or include any math tutoring). Stake’s (1995) case study design was the most applicable to my situation, since it contains flexibility and follows a social constructivist epistemology (Yazan, 2015).

Stake (1995) defines a case study as a ‘holistic’ (special attention to mutual links between the phenomenon and its contexts), ‘empirical’ (based on observation), ‘interpretive’ (researchers’ intuition), ‘empathic’ (emic perspective to reflect on how people think) and integrated method that values the different standpoints and interpretations researcher and participants have (“Case study by P2YK”, 2016, para. 4).

Stake’s (1995) focus was primarily on a robust body of data emanating from interviews, observations, and the review of documents, since to him, the triangulation of data, is a measure of the quality of the analysis. Triangulation is the examination and analysis of different types of data emanating from different sources and which may align with various theories or perspectives (Yazan, 2015; Stake, 1995). Flexibility in the design, according to him, needed to allow for modifications and adjustments that could arise as knowledge of the participants and their reactions via observations were acquired.

According to Stake (1995), there are three main case study types – intrinsic, instrumental and collective. The intrinsic case study is focused more on the case, or the group, being explored, while the instrumental case study is used to gain understanding of a phenomenon involving the case. The collective case study incorporates many instrumental case studies and explores them as a collection.

Since instrumental case studies focus on the research question while the associated data analysis searches for patterns or themes that allow for future comparisons with other cases, my research followed the design of an instrumental case study. The case – my participant group –
was studied to acquire knowledge and understanding of math anxiety and how contemplative practices affected it.

3.2 Population

This case study examined a population contained within a western Canadian college. This college offers a variety of health, trades, and technology programs as well as the first two years of Arts and Science university transfer courses. Called an “Associate Degree”, students enrolled at the college can transfer their university transfer course credits to a third-year university program. Students who attend the college are a mixture of students entering straight after graduating high school, to students with full-time jobs and families, from domestic to international students. It is of note that classes at the college are smaller than most university institutions (ranging from 20-40 students per class).

Students enrolled in the first-year mandatory business math course (MATH 114), the first-year mandatory arts math course (MATH 111), and the first-year mandatory science math course (MATH 112) comprised the population for this study and included approximately 450 students in total. According to the mathematics and statistics department chair, these courses traditionally had a high proportion of students with math anxiety, some of whom even delayed taking their respective mandatory course until the end of their program (J. Hobart, Personal communication, Feb 28, 2019). Despite intense recruitment efforts, only six participants in total agreed to participate in the research and all were female.

As part of my role as an instructor at the College, a research assistant (RA) was available through internal grants-in-aid. The RA was a second-year technology student, coming to the college as a mature student after completing the first three years of a Bachelor of Science degree. He was hired to assist in the transcription of the focus group discussion and the semi-structured
interviews. He worked on the analysis of the Five Facet of Mindfulness Questionnaire (FFMQ) questionnaires. Considering the low participation rate of recruited participants and the complete lack of male participants, my advisor and I decided to include the RA in the dataset. We adhered to ethical standards regarding undue influence of the RA by interviewing him separately. He did not interview the participants nor take part in the collection of the data. From his distinctive perspective, the RA aided in the triangulation of the data. Table 1 lists the demographics of the research participants.

Table 1: Participant Demographics

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<th>Participant</th>
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<th>Year in Program</th>
<th>Gender</th>
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</tbody>
</table>

3.3 Participant Confidentiality and Safety

Ethics approval via a harmonized process through both UBC Okanagan and Okanagan College was required since the research involved human subjects (participants). Students were informed beforehand as well as during every session and during the interviews, that they could recuse themselves at any point, without any penalty or consequences from either institution.

To satisfy ethics, to respect the confidentiality of students and to protect their privacy so that they could feel safe in their sharing, all collected data was coded. Participant names were
replaced with a coded number, MACP01-MACP06. Consent forms and all records that associated participants’ names with coded numbers are currently being and will continue to be kept separate from the anonymized data. Though all students in the population may not have met the age of majority, all were from at least first year college and, as college students in the business program, possessed enough capability to read and understand the consent form.

All paper and electronic documents (consent forms, questionnaires, interview transcripts, audio files and practice logs) are being and will continue to be stored in a secure location in my supervisor’s office at UBC Okanagan. All paper documents will be archived for five years following any publication and then will be destroyed via shredding. All digital data, including audio recordings of the interviews, are and will continue to be stored on a password-protected, encrypted, digital storage device, also in a secure location for five years following any publication until the device is formatted and all files are deleted.

The consent letter also included my contact information if anyone desired to speak with me directly or voice concerns in a private setting. They also had contact numbers of both research ethics boards if they had any issues with me personally or professionally.

Finally, for the well-being of participants, only innocuous practices were included in the sessions. Emotionally questionable ones, such as the body scan, were avoided since they could trigger trauma in individuals who have experienced difficult life experiences (Berila, 2014). Participants were already exposing their math anxiety; they did not need further intrusions.

3.4 Data Collection

In this study, data collection included:

1. the field notes, including observations, from each Mindful Math session,

2. the pre- and post-FFMQ,
3. the focus group discussion,
4. the individual semi-structured interviews.

Please refer to Appendices A (the FFMQ), B (the Focus Group Questions), and C (the Semi-Structured Interview Questions) for exemplars of the measures used in this research. During each of the six Mindful Math sessions, notes recognizing the strength and the challenges had by the participants as well as the reactions of the RA were taken. These notes not only documented what was seen, but also included possible modifications for future sessions to better meet the needs of the participants. Taking the time to understand the lives and the culture of the participants as well as setting aside preliminary assumptions was also important, according to Stake (1995).

The FFMQ is a measure of the level of mindfulness in relation to five facets. The FFMQ examined five facets of mindfulness: observing, describing, acting with awareness, nonjudging of inner experience, and nonreactivity to inner experience (Baer et al., 2008). Items were rated on a 5-point scale (where 1 = almost never to 5 = almost always). Though a number of self-reported mindfulness scales exist, the FFMQ is the second most commonly used scale, after the Mindfulness Attention Awareness Scale (MAAS, 5,054 citations to 2,660, based on Google Scholar, October 20, 2016, cited in Van Dam et al., 2017). The MAAS measures only a single factor based on awareness and attention, which did not provide enough depth for this research.

The pre-FFMQ was written during the first session, while the post-FFMQ was completed during the sixth and final session. Though the questionnaires are identical, the pre- and post-FFMQ allowed for comparison between the five facets of mindfulness. This analysis is discussed in Results.
Finally, further qualitative data was collected from the participants via the focus group discussion and the individual semi-structured interviews. The group discussion included a dialogue pertaining to various contemplative practices. For data triangulation, notes were taken and the discussion was audio recorded (with consent). The RA transcribed the audio-recorded discussion and I verified the transcription by re-listening to the recording.

The individual semi-structured interviews were performed the three weeks following the final session, with participants who had given consent. At this time, the individual semi-structured interviews were conducted with the RA. As included earlier, Creswell and Creswell (2018) wrote that the “researcher as key instrument” (p. 180) is an important component of a qualitative design, implying the importance for the researcher to collect the data themselves, through observations or when interviewing participants. Hence, I interviewed each participant personally and had the RA transcribe each of the interviews, except for his own. Stake (2010) included that “member checking” was an important way to validate data – that is, having participants verify their quotes. Due to the high levels of anxiety during final exam time, the participants did not reread their transcripts.

3.5 Data Analysis

Inductive reasoning was used when coding qualitative data to identify emerging themes. Tesch’s Eight Steps in the Coding Process (Creswell & Creswell, 2018, p. 196) provided important direction in coding the qualitative data. The process began with the reading of the collected data in its entirety, followed by a focus on the semi-structured interviews and a search for similar words and topics. The open-ended last question in that interview allowed many ideas to be incorporated. Afterward, these themes were compared with those emanating from the other datasets, one at a time. Pertinent categories were kept and then the analysis began. Triangulation
of themes across the different datasets ensued. Simple descriptive statistics were performed on
the data emanating from the questionnaires and were used to support the determined themes and
how they related to the research question.

In case studies, the concept of triangulation is of utmost importance for validating data.
Triangulation allows the researcher to investigate the case or the phenomenon from various
perspectives. In this study, the four different types of triangulation referenced by Stake (1995)
were incorporated:

1. Triangulation coming from data sources: Data in this study emanated from field
   notes, questionnaires, focus groups, and semi-structured interviews.
2. Triangulation from investigators: Though other academics did not participate in this
case study, the RA was incredibly helpful to elucidate different perspectives and
   emphasize certain participant reactions.
3. Triangulation of theories: Though math anxiety is a field unto its own, concepts
   coming from mathematics, educational psychology, and contemplative practices were
   incorporated to investigate theories from a broader, more objective perspective.
4. Triangulation of methodologies: Qualitative data analysis based on the focus group
discussion as well as the semi-structured interviews were aligned with the
   quantitative data analysis resulting from the questionnaires.

The following chapter will discuss the results of the data analysis detailed in this chapter
and will demonstrate the triangulation methods described herein.
Chapter 4: Results

This chapter presents the data collected during the six *Mindful Math* sessions, held in September, October, and November of the fall 2019 semester. As was described in the previous chapter, data was collected from field notes, observations, the pre- and post-Five Facet of Mindfulness Questionnaire (FFMQ, refer to Appendix A), a focus group discussion (held during the sixth session, refer to Appendix B), and individual semi-structured interviews (refer to Appendix C). As mentioned in the previous chapter, Tesch’s Eight Steps in the Coding Process (Creswell & Creswell, 2018, p. 196) were used when coding the qualitative data, beginning with the semi-structured interviews and then extending out to contain all the data. Relevant and repeating themes were kept and then the analysis began. Triangulation of themes across the different datasets arose and was confirmed using results emanating from the questionnaires. Discussion of the results in conjunction with the research question occurs in the following chapter.

Six themes arose from the analysis of the field notes, the observations, the focus group discussion, and the semi-structured interviews. Results from the Five Facet Mindfulness Questionnaire (FFMQ, refer to Appendix A) support Theme 2 and will be discussed therein. Collectively, the identified themes are:

- Theme 1: Observed Positive Physical Changes
- Theme 2: Increase in Mindfulness Facets
- Theme 3: Changing View of Math Anxiety
- Theme 4: Change in Number-Induced Math Anxiety
- Theme 5: Perceived Effects of Practices on Math Anxiety
- Theme 6: Importance of Routine and Small Groups

Throughout the research, the participants’ names were coded MACP01 through MACP06 to ensure their confidentiality. Observations emanating from the field notes are given with each
theme, supported by participant statements resulting from the focus group discussion or the semi-structured interviews (identified by their encoded number) or by the RA (labelled RA).

4.1 Theme 1: Observed Positive Physical Changes

Observations emanating from field notes demonstrated positive physical changes across the sessions. In the first session, the participants were sitting apart with hunched shoulders and arms clenched over their chests. Since the participants were separated physically across the classroom, it was difficult to have paired conversations.

Over the course of the Mindful Math sessions, participants were noticeably more comfortable and at ease with themselves and with each other. For MACP04, the difference between when we had first met to the last session was most evident. As she sat with the other participants and was involved in the focus group discussion, she shared “I feel comfortable here and valued. I never speak in math class. I feel like I’m wasting everyone’s time. Or that’s how they look at me. I found a voice here. Thank you.”

MACP05 would rub her hands and look around furtively during the first three sessions. By the time the fourth session took place, she stopped these actions and would sit back in her chair, with her hands on her lap. She contributed that “this new space [classroom] isn’t visible to everyone. I don’t have to worry who’s looking in.” By this session, all the participants would sit together. MACP05 added “I also know that I’m not alone. Other people here feel like I do. There’s something comforting about that.” The RA, during his semi-structured interview, noted that “in the first session, there was a lot of slouching and tucked-in shoulders. Those were the things that stood out the most, which eventually got better.”
4.2 Theme 2: Increase in Mindfulness Facets

Data collected from the field notes, the semi-structured interviews, and the FFMQ (see Appendix A) responses were indicative of perceived and self-reported changes relating to anxiety and stress.

During their interviews, MACP01 and MACP04 both talked about their initial anxiety when they entered the first session:

During the first session, I was worried everyone was going to judge me. Instead, the sessions become a safe place. I don’t feel you get much of a break when you’re here [at the college] and you’re doing your classes. Even when you have a break from classes, you’re probably studying or something like that. There’s never a time where you can actually calm down. It’s nice to make a connection with other people and to make time on campus. [MACP01]

The first session… I was really anxious about the session, who would be there. And then it just changed. Even this room, it’s so warm and friendly, away from strangers. No need to rush. This has been great. [MACP04]

In the field notes, it was written that MACP03 commented on how relaxed and grounded she felt during the Pause practice (see Appendix D) in Session 2, comparing the sensation to being rooted like a tree, giving her strength. She invited everyone to think in this way. The rest of the participants appreciated that perspective and used that visual going forward.

MACP02 appreciated the Loving-Kindness (see Appendix D) meditation in Session 5, since it occurred while she had strained relations with a friend. After the meditation, she decided to give her friend space and accepted the situation as it was.

Before the meditation, I blamed myself for not doing enough. I don’t know what happened, we were so close. I can’t force her to tell me. Loving-Kindness made me think that maybe it’s not me. Maybe there’s something else going on. I can give her space. If she wants to talk to me, I’ll be here. [MACP02]
In the last session during the focus group discussion, MACP04 shared that she was sleeping better due to regular, focused breathing. She found the breathing so relaxing that it decreased her anxiety but made her sleepy. Hence, she reserved it for home-use only.

All participants took the pre-FFMQ; however, only three participants completed the post-FFMQ. The results associated with the three participants who completed both the pre- and the post-FFMQ are found in Table 2. The results presented are averages out of five, based on the Likert scale values mentioned in Chapter 3: that is, from 1 (almost never) to 5 (almost always). The averages for all facets are calculated using eight values, except for Nonreactivity which uses only seven. The increases are also based on averages. Hence, even a small increase of 0.1 means that a participant increased by 0.8 (or 0.7 for Nonreactivity) overall.

Table 2: FFMQ Results

<table>
<thead>
<tr>
<th></th>
<th>MACP01</th>
<th></th>
<th>MACP02</th>
<th></th>
<th>MACP04</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Observing</td>
<td>4.0</td>
<td>4.5</td>
<td>3.0</td>
<td>3.8</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Describing</td>
<td>3.0</td>
<td>3.4</td>
<td>4.5</td>
<td>4.8</td>
<td>3.9</td>
<td>3.8</td>
</tr>
<tr>
<td>Acting with</td>
<td>3.1</td>
<td>2.5</td>
<td>2.5</td>
<td>3.0</td>
<td>2.8</td>
<td>3.0</td>
</tr>
<tr>
<td>Awareness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonjudging of</td>
<td>2.9</td>
<td>2.8</td>
<td>3.5</td>
<td>4.3</td>
<td>3.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Inner Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonreactivity</td>
<td>2.3</td>
<td>2.6</td>
<td>2.9</td>
<td>3.7</td>
<td>2.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Inner Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.1</td>
<td>3.2</td>
<td>3.3</td>
<td>3.9</td>
<td>3.5</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Over the span of nine weeks, changes occurred in the mindfulness levels of these three participants. In fact, all improved in their overall mindfulness levels. All FFMQ participants increased in both the Observing and Nonreactivity categories, while two of the three improved in the categories of Describing and Acting with Awareness. The positive changes in Nonreactivity and Nonjudging relate directly to self-reported positive emotional changes.
4.3 Theme 3: Changing View of Math Anxiety

Self-reported math anxiety was one of the criteria for joining the sessions. For the participants, previous negative feelings and emotions about math were compounded in classrooms when “expectations aren’t spelled out” [MACP01], when “peers do things better and more effortlessly” [MACP01] or when “you don’t understand” [MACP04]. Home environments also influenced the way participants felt about math, in particular when there is a lot of pressure from family members [MACP02].

However, the semi-structured interviews and the focus group discussion demonstrated that a different perspective on math and math anxiety arose.

I got the feeling that “everyone can do this” from the sessions. [MACP01]

I’m thankful for my instructor as well. He [her math instructor] was very understanding. He took the time to come to campus and helped me study. He gave me different methods of thinking. [MACP04]

The fact that a mathematician (myself) worked to address math anxiety affected the participants, opening their mind to other possibilities.

You were so positive and happy and excited about math. You made it really accessible. [MACP02]

Perhaps not all math people are bad. [MACP03]

You changed my perspective on thinking about math. You’re so passionate and take a lot of pride in what you do. I respect that. [MACP04]

The Mindful Math sessions did not include any form of tutoring nor working through any math problems.
4.4 Theme 4: Change in Number-Induced Math Anxiety

The discussion of how math made participants anxious or stressed regularly surfaced throughout the sessions. Moreover, anxiety arising from the mere presence of numbers occurred during the first session in very visible ways and was well documented in the field notes. Since the anxiety was related to numbers and counting and not to more advanced mathematical tasks and operations, the term ‘number-induced math anxiety’ is used here to differentiate it from the broader, more general ‘math anxiety’.

When we started by counting ‘one’ on the in-breath and ‘two’ on the out-breath, in an attempt to bring attention to the breath, participant physical discomfort was obvious. When the numbers ‘one’ and ‘two’ were changed to ‘in’ and ‘out’, the participants relaxed in consequence. Another exercise was performed to determine the number of breaths taken in a minute during normal or non-anxious times. The participants were invited to count the number of breaths achieved in a minute. The purpose was to determine a baseline and a returning point when their breathing increase in frequency due to stress or anxiety. MACP04 and MACP05 became quite anxious when counting breaths, changing their breathing patterns. The exercise was promptly stopped. A sense of tranquility returned once the exercise was discontinued and breathing seemed to return to normal. Finally, the first session ended with the completion of the pre-FFMQ. One participant [MACP05] was so disturbed by the numbers used in the questionnaire that she only completed one side of the page.

The fourth session began with the 5-4-3-2-1 practice (see Appendix D). Unlike the first session, the participants became more vocal, forging links between this practice and mindful eating and drinking. They also felt that this practice could be easily performed, even in class or at the beginning of a test, due to its brevity. Not only did the use of numbers in this case not seem
to bother anyone, no further evidence of number anxiety appeared during the remainder of the sessions. This practice turned out to be the favourite of all.

4.5 **Theme 5: Perceived Effects of Practices on Math Anxiety**

From the semi-structured interviews, there was a consensus that all participants had suffered from math anxiety for a duration of at least four years, up to “as long as I can remember” [MACP04]. The participants attributed this anxiety to feeling overwhelmed [MACP01, MACP02], feeling pressured to succeed [MACP01, MACP02], being intimidated by the content [MACP04], not doing well in math courses or not understanding the material [MACP01, MACP04].

When starting their most recent math courses, anxiety, stress, and fear were the most common feelings. During the semi-structured interviews, MACP01 stated that during her most recent class, she was “not as anxious or stressed out, but there is still pressure to succeed”. As for MACP04, her most recent class “was a test and it was stressful. I kept telling myself ‘I don’t know anything else and I’ve tried my best’ and ‘it’s okay, it’s not the end of the world’. I have less judgement than I had before”.

Only three of the participants participated in the focus group discussion and the semi-structured interviews. Two of the participants had seen mindfulness practices before, while one had not. The 5-4-3-2-1 practice was the favourite of all “since it’s short and can be used in class before a test” and was a practice that was expected to be used going forward. MACP01 found it important to share her experience with the math class visualization:

> Using the visualization, I feel more in control in real life. I’m more open to trying other techniques now and use the 5-4-3-2-1 during tests. It allowed me to put myself in the situation that’s stressful, but I can control my reaction and prepare for it. I had time to cope. It’s like practicing to be calm in class and practice makes perfect.
MACP04 would recommend to others who felt anxious about math to try some of the practices: “I would. It may not work for them, but it’s worked for me.” MACP02 stated that “I think these mindful practices are just good to do in general for life.” MACP01 also shared that “The sessions helped me to be less hard on myself. ‘This is just math, it’s okay’. I can actually try and move on with it.” Finally, MACP04 added that “I don’t hate it [math] anymore. It’s just something that I have not yet grasped and I need to think about it in a different way. It’s just frustrating as something that I don’t understand.”

I learned to use my five senses, to be in the present moment, to bring my anxiety down. When my anxiety increased, I stopped to feel the desk, the paper, the pencil. It helps. I also pay closer attention to my breath and close my eyes to visualize a happy place. Using these techniques when doing homework at home, when in class and during tests help, I can remove physically myself from the anxiety cycle to refocus ‘okay, now I know where I am. I just need to fill these things out and then I can stop’. [MACP04]

While the participants noticed differences in their attitudes and their emotional responses, they all reminded me that sessions and practices are not enough to solve the math anxiety issue.

Mindfulness practices alone won’t do. If you don’t know math, you might calm yourself down, but then you’re still going to go back to not knowing math. [MACP02]

You can meditate all day, but you still need to learn, to practice the math. [MACP01]

4.6 Theme 6: Importance of Routine and Small Groups

From the field notes and emails from the participants, it was clear that MACP03, MACP05 and MACP06 had a hard time fitting in the sessions especially on a test day. Meanwhile, MACP01, MACP02 and MACP04 made a point to attend because it was test day and chose to pause and de-stress. According to the field notes and the semi-structured interviews, the change in location from a busy classroom to a quieter location was very helpful, allowing
space for relaxed discussions and for the building of relationships. Moreover, regular weekly sessions would have been preferred, to the modified format that was offered:

Weekly sessions would have been nice, throughout the term. It would put a reminder in my brain every week that I can take a pause in class, to take a few moments away during a test, to get away from the stress for a minute and get myself out of my head. [MACP01]

I’m going to miss them [the sessions] and all of you. It helped me to start a routine. [MACP02]

With such a small group, the conversations became more lively and took up a lot of time. There was the opportunity to get to know the participants better and understand where they came from for their anxiety perspectives. Connections were built. [RA]

This chapter presented six themes that emerged from the data collection. The first five themes are indicative of the self-reported and perceived effects of contemplative practices as well as changes in the levels of math anxiety of the participants. As seen in the Literature Review, the correlation between math anxiety and math performance, the link between math anxiety and math avoidance, and the effect of math anxiety on working memory were presented. Also, the beneficial effects of contemplative practices, including mindfulness techniques, at the post-secondary level, some in the math classroom, were also disclosed. The next chapter will provide a succinct analysis of how the identified themes inform the research question and fill in current gaps in the literature.
Chapter 5: Analysis and Discussion

The previous chapter presented the results emanating from the data collected for this research examining contemplative practices and math anxiety in students enrolled in first-year post-secondary mandatory math courses. This chapter will discuss the results, establish links with the existing literature, share limitations, and introduce possible future directions.

As indicated, six themes emerged from the analysis of the field notes, observations, the focus group discussion, the semi-structured interviews, and the Five Facet Mindfulness Questionnaire (FFMQ, see Appendix A).

- Theme 1: Observed Positive Physical Changes
- Theme 2: Increase in Mindfulness Facets
- Theme 3: Changing View of Math Anxiety
- Theme 4: Change in Number-Induced Math Anxiety
- Theme 5: Perceived Effects of Practices on Math Anxiety
- Theme 6: Importance of Routine and Small Groups

For the purpose of concision, Themes 1 through 6 will be referred to as T1, T2, …, T6 throughout the remainder of this chapter.

5.1 Analysis of the Research Question

The purpose of this case study is to address the question:

**Do contemplative practices decrease perceived math anxiety at the post-secondary level?**

Based on the thick descriptions taken from observations emanating from the field notes, the identified themes support the premise that contemplative practices can help in decreasing math anxiety. Of interest was the realization that a large part of the students’ math anxiety was related to number-induced math anxiety (T4). Number-induced anxiety was described in the previous chapter as math anxiety brought on by the use of numbers and/or counting. Observations emanating from field notes demonstrated how the students’ physical posture
became more relaxed as the sessions progressed (T1). Namkung, Peng, and Lin (2019) stated that “even simply numerical tasks, such as counting, can also elicit MA [math anxiety] among adults” (p. 463), a statement which rang true after the first Mindful Math session.

Introducing the contemplative practice of focused breathing, where participants took intentional deep breaths before doing a mathematical task proved to be beneficial, as anticipated by Brunyé et al. (2013). By the fourth session, the students’ willingness to engage with the 5-4-3-2-1 practice (see Appendix D) was noticeable. The reported data indicated that the number-induced math anxiety had diminished. There were no further concerns reported with numbers, supporting a more positive mindset towards simple mathematical tasks.

The case study results also demonstrated that with regular practice over the span of nine weeks, participants were able to manage their math anxiety, demonstrating better control of their emotional reactions to math anxiety. Specifically, the self-reported FFMQ pre- and post-results demonstrated an overall increase in mindfulness levels as well as an improvement in the two facets of Observing and Nonreactivity to inner experience, for all three participants (T2). Baer et al. (2008) described the Observing facet as “noticing or attending to internal and external experiences, such as sensations, cognitions, emotions, sights, sounds, and smells” (p. 330). The increase of the Observing facet over the course of the sessions, as seen in the FFMQ, can be linked to the regular use of the Pause and the 5-4-3-2-1 practice by all participants, two practices which focus on observing feelings, thoughts and sensations.

As for the Nonreactivity to inner experience facet, Baer et al. (2008) elaborated that it “is the tendency to allow thoughts and feelings to come and go, without getting caught up in or carried away by them.” (p. 330). The improvement in this facet is noticeable for all participants
not only via the questionnaire results, but also through the statements made during the semi-structured interviews, demonstrating a changing view of their own math anxiety (T3).

“This is just math, it’s okay. I can actually try and move on with it” [MACP01].

“I don’t know anything else and I’ve tried my best” [MACP04].

The genesis of math anxiety for the participants in this research (relating to T3) was discussed during the first session and, at a later date, during the focus group discussion and the semi-structured interviews. The collected data identified classroom environment and instructor behaviours as variables that impacted on math anxiety and matched Shishigu (2018), Change and Beilock (2016), and Ashcraft (2002): MACP01 added that she was “afraid to ask questions in class, because if it’s a basic question he’ll [the instructor] just write it off like ‘oh you should know that from grade X’”. She also added that “when a teacher assumes that you’re at the same level that they’re at, that’s a bit hard. When he skips steps and I don’t follow, I struggle” [MACP01]. Not all instructor behaviours were associated with negative sentiments. In fact, MACP04 spoke highly of her instructor, “He took the time to come to campus and helped me study.” As for the classroom, MACP04 did not feel that she had a voice in her class and was afraid to ask questions, stating “I feel like I’m wasting everyone’s time. Or that’s how they look at me”. MACP05 shared that students who sat behind her “giggled and laughed when I asked a question. I overheard them saying how ‘stupid’ the question was. I stopped asking questions after that.”

Another variable affecting math anxiety identified by the students was the influence of family and peers: MACP02 related that some of her math anxiety emanated from the pressure imposed by her family, “I’m Asian, so my family expected me to do well in math”. MACP01 claimed that she was a perfectionist and cared what others in the class thought, “there was a
student in front of me and he was like, he doesn’t show up to class and he doesn’t take notes in class, but he got 100%. That hurts”.

The last identified variable affecting math anxiety was previous math performance: MACP01 had grades in the high 80s, low 90s in high school before she became ill and fell behind. “I missed two years and then jumped right back into math. But I was like 2 years behind. I lost confidence and didn’t do so well anymore. It was overwhelming to even think about catching up.”

Along with the identification of the roots of their personal math anxieties, the consequences of math anxiety for the participants were also identified from field notes and semi-structured interviews, relating to T3:

**Poor math performance:** The consensus among participants during the first session was that they did not do as well as they would like in math. For example, two participants felt that they put in a lot of time that “didn’t pay off” [MACP01] or “didn’t amount to anything” [MACP04] on assignments or tests.

**Poor working memory during math tests/finals:** Participants shared that they often “blanked” on a test or final, which means that they prepared yet forgot everything upon entry to the test. For MACP01, the math class visualization practice diminished the anxiety and made her feel more comfortable when in the math classroom. MACP04 used the 5-4-3-2-1 practice to calm herself down “When my anxiety increased, I stopped to feel the desk, the paper, the pencil. It helps” and to talk to herself in a positive way “okay, now I know where I am. I just need to fill these things out and then I can stop” [MACP04].

**Math avoidance:** During the second session, MACP03 and MACP05 shared their math avoidance. MACP03 delayed taking her mandatory business math course until the second year of
her diploma due to her discomfort. “It made a bunch of first year courses way harder. I didn’t know the math” [MACP03]. MACP05 chose to only do the diploma, instead of the degree, “since there’s way less math”.

T5 is related to T1 through T4, since they all related to either contemplative practices or math anxiety. Furthermore, T5 holistically addressed the research question which examines whether contemplative practices have a positive effect on math anxiety. As expressed in Results, all participants believed that they suffered from math anxiety when they first joined the Mindful Math sessions, based on how they defined their own personal math anxiety (cf. T5 in Chapter 4). In many ways, T2, T3, and T5 are closely linked, since the change in the facets were supported by statements made relating to math and math anxiety during the focus group discussion and the semi-structured interviews. For example, MACP04’s realization that “I don’t hate it [math] anymore” aligned with the increased ‘Nonreactivity’ facet for all three participants. She gained a greater appreciation toward math and no longer vilified it. Tobias (1993) wrote that “fearing math makes us wary of activities that may involve [math]” (p. 33).

This changing view of math anxiety (T3) attributed to the practices (T5) may lead to less math avoidance. The numerical improvement demonstrated in the FFMQ (T2) is confirmed by statements emanating from the semi-structured interviews, supporting T5, such as “everyone could do it [math]” (MACP01) or that it was “accessible” (MACP02), demonstrated a more positive view of mathematics and decreased math anxiety.

Finally, MACP01 determined that “the sessions helped me to be less hard on myself”, causing her less anxiety in test and exam situations and, in theory, improving her cognitive resources (Ashcraft & Kirk, 2001).
The ability to manage emotions (T2 and T5) was supported, in part, by the routine established in the *Mindful Math* sessions including the sense of community that emerged from the discussions about math anxiety. T6 indicated the importance of creating a safe and nurturing community of learners. The semi-structured interviews and focus group discussion demonstrated that students were more comfortable with familiar surroundings and familiar faces. A smaller group of participants provided a context upon which relationships built on trust and respect could emerge. As is demonstrated by the Tree of Contemplative Practices (cf. Figure 1), all practices are rooted in “communion & connection”, signalling the foundational requirement of community and relationship building when incorporating mindfulness practices. On a last note, the relationship with the instructor was an important aspect to consider when addressing concerns relating to math anxiety. From her semi-structured interview, MACP04 was thankful for her instructor for being understanding, taking the time for her and “giving her different methods of thinking”.

Across the sessions, a change in physical reactions (T1 and T4), emotional responses (T2, T4, and T5), and attitudes (T3) toward math occurred – from no longer hating it, to not feeling as anxious or stressed, to accepting the difficulty. “It’s just frustrating as something I don’t understand” [MACP04]. The participants attributed these changes to the sessions and to the practices. After all, as MACP04 expressed it, “it’s worked for me”.

The results of this research indicate that, within this specific context, introducing contemplative practices is an effective behavioural intervention which combined stress management and reduced math anxiety. Hembree (1990), who concluded that the most effective solutions for math anxiety were behavioural treatments used in combination with anxiety regulation and relaxation techniques, supports this result. MBSR and its related smartEducation
program are proven to benefit emotional regulation and resilience (Ragoonaden, 2017; Shapiro et al., 2011). Brunyé et al. (2013) concluded that focused breathing before a test or final improved performance. Ashcraft and Kirk (2001) determined that worrying used valuable cognitive resources, a problem that mindfulness (and thereby contemplative practices) could alleviate (Bellinger, DeCaro, & Ralston, 2015; Shapiro, Brown, & Astin, 2011).

This research involved qualitative analysis of a case study. From the analysis of the themes, it is clear that the incorporation of contemplative practices into the lives of these post-secondary students made a difference to their self-perceived math anxiety. The next section will discuss prospective consequences of reducing math anxiety, the limitations to such a study and possible future directions.

5.2 Discussion

The research question found in this thesis “Do contemplative practices decrease perceived math anxiety at the post-secondary level?” was founded on the principle that math anxiety does exist. At issue, is how to counteract math anxiety at the post-secondary level. The goal was to investigate the research question via an instrumental case study regarding whether contemplative practices decreased math anxiety. The triangulation of field notes, the observations, the focus group discussion, and the semi-structured interviews, identified the source of math anxiety and investigated the use of contemplative practices as viable interventions to reduce that anxiety.

After all, if contemplative practices CAN decrease perceived math anxiety, then more cognitive resources may be used to solve math problems, leading to greater performance (Ashcraft & Kirk, 2001); greater math performance could minimize math anxiety (Choe et al., 2019; Namkung et al., 2019; Shishigu, 2018; Ma, 1999), leading to less math avoidance (Ibid;
Ashcraft, 2002; Hembree, 1990). Less math avoidance implies greater participation in mathematics courses and careers, fulfilling needs in North American society (Beilock, 2020; Perry, 2004; Ashcraft, 2002) and further decreasing math anxiety (Choe et al., 2019).

Hembree (1990) determined that students with high levels of math anxiety saw a decrease in anxiety levels when they took more math courses. Hence, taking more math courses could only lead to greater math competency as skills become honed. Math anxiety is clearly rich in its connections. Changes in its level can affect change elsewhere, from avoidance to performance, making it a worthwhile pursuit.

All three meta-analyses (Namkung et al., 2019; Ma, 1999; Hembree, 1990) determined a negative correlation between math anxiety and math performance, with the correlation coefficient ranging from $r = -0.34$ (Namkung et al., 2019) to $r = -0.27$ (Hembree, 1990; Ma, 1999). Choe et al. (2019), Namkung et al. (2019), Shishigu (2018), and Ma (1999) also concluded that not only does high math anxiety lead to poor math performance, but that poor math performance also leads to high math anxiety.

As we have seen, even in this small case study, there are many reasons for math anxiety outside of performance, including challenging classroom environments or instructor behaviours which may not be conducive to asking for help or for being positive. Perry’s (2004) anecdotal evidence identified “different types of math anxiety, ranging from “moderate test anxiety”, to students having “mixed feelings” toward math, to a student having an insensitive or incompetent math teacher at some point during their earlier education, to a student having limited mathematical understanding or ability. Comprehensive studies in the area of math anxiety do discuss some of the causes of math anxiety:
1. Shishigu (2018), Chang and Beilock (2016), and Ashcraft (2002) determined that the classroom environment and instructor behaviours directly affect math anxiety levels.

2. Shishigu (2018) and Chang and Beilock (2016) added that peers and parents also have a role in math anxiety levels.


In the same above studies, the consequences of math anxiety were also discussed:

1. The link between math anxiety and the use of cognitive resources (Bellinger et al., 2015; Ashcraft, 2002); that is, math-anxious students see a drop in cognitive resources that may otherwise have been allocated to solving math problems or performing computations.

2. The negative correlation between math anxiety and math performance (Choe et al., 2019; Namkung et al., 2019; Shishigu, 2018; Ma, 1999; Hembree, 1990).

3. The link between math anxiety and math avoidance (Choe et al., 2019; Namkung et al., 2019; Shishigu, 2018; Perry, 2004; Ashcraft, 2002; Hembree, 1990).

This research utilized qualitative data associated with math performance to verify the math anxiety-math performance relationship. The goal was to investigate whether contemplative practices decreased math anxiety at the post-secondary level. The triangulation of field notes, the focus group discussion, and the semi-structured interviews, identified the source of math anxiety and investigated the use of contemplative practices as viable interventions to reduce anxiety.

Burack’s (2014) framework was instrumental in conceptualizing the Mindful Math sessions. Within this framework, the instructor’s self-practice is an important consideration. Facilitating the practice of others required depth (like any form of teaching) and embodiment.
This level of authenticity provided students with a safe and stable environment in which to explore their own anxieties.

Berila’s (2014) warnings about possible traumatic reactions in oppressed or marginalized students were also important considerations. By taking the perspective that math-anxious students have been oppressed by the subject or marginalized due to their lack of competency, practices which were more accessible to students and worked toward emotional regulation and building resistance were chosen.

Mathematicians, math teachers and academics in mathematics education alike recognize that it is important to address math anxiety at an early age (if Namkung et al. (2019) is correct, by grade 4). By researching at the post-secondary level, is it too late for students to work on decreasing math anxiety? Based on literature and research, math anxiety may be a ‘chicken or the egg’ scenario. According to Shishigu (2018), Small (2017), Chang and Beilock (2016), Ashcraft (2002), and Paulos (1988), peers, teachers and parents can all contribute to the math anxiety of students.

If influences are as Shishigu (2018), Small (2017), Chang and Beilock (2016), Ashcraft (2002) and Paulos (1988) proposed, then influencing post-secondary students is not too late. After all, are post-secondary students not peers, parents (already or soon-to-be) and/or prospective teachers? If math anxiety is part of a cycle involving many stakeholders, then it can be broken at any point in time, from childhood to adulthood.

5.3 Limitations

As a researcher, my identity as a mathematician and an education graduate student guided my teaching practice. Recognizing that I am not a counsellor, I chose to limit the contemplative practices to ensure the well-being of my students. Though certain contemplative practices such
as the body scan may have been useful (as evidenced by MBSR programs and emotional regulation, Shapiro et al., 2011), Berila (2014) warns against re-exposing participants to possible traumatic events, which would have increased the risk level of students involved in this research. The participants had enough to contend with their math anxiety and a minimal risk study is what had been applied for via ethics.

There are limitations of this research, as a case study was used, hence the conclusions may not be generalized. Due to the limited population size, the data collected refer to the specific context of college environment situated in the Interior of British Columbia, Canada. The first challenge faced involved the recruitment. The recruitment at the College was challenging, in part due to the nature of a college. Many students work (either part-time or full-time) and have family obligations, often because they attend a bit later in life. Not as many students are fresh from high school as at a university. Time constraints are certainly an issue as is timetabling. The College is growing and running out of space, so finding a room on campus is challenging at best, let alone a safe, quiet, comfortable space which is conducive to sharing and practicing.

The gendered population in my case also presented some challenges in terms of the homogeneity of the perspectives. To encourage a higher level of participation and to be more inclusive, the approach taken in my future doctoral work will be revised to include describing math anxiety and explaining different types of possible contemplative practices.

When this research is extended, planning for smaller groups in advance, choosing more secluded rooms or perhaps the option of meeting off-campus will be included. For example, activities such as mindful movement or mindful walking could be undertaken without compromising the participants’ anonymity or confidentiality. Meeting weekly would also be important. To allow participants to be comfortable voicing their perspectives, an allowance of
extra time and space for the building of trust and relationships would also be offered. Some of these logistical issues arose as part of the limitations of this research and will be discussed further in the next section.

5.4 Future Directions

The contemplative practices included in the Mindful Math sessions show promising results, suggesting that this enterprise may be effective as a support for students confronting anxiety inherent to mathematics courses or STEM-related fields. While also supporting overall student well-being, the coping skills developed in such a program could act as an important component of the classroom environment. This could, in turn, ensure the emergence of a culture of acceptance for students of all math proficiency levels and further foster the co-curricular learning environment for all.

Returning to the gendered nature of contemplative practices, Rojiani et al. (2017) determined that women responded better than men did to mindfulness practices used in an academic setting at the post-secondary level. They also posited that modifications to mindfulness-based interventions used might incur greater improvements for men. In one of his observations, the Research Assistant (RA) commented on the possible difficulties for a male participant during certain videos (e.g., Neff’s “The Space between self-esteem and self-compassion”, TEDGlobal 2013, 2013) or practices (e.g., the Loving-Kindness practice). Even though Hembree (1990) determined that “males [were] less affected by math avoidance” (p. 38), “male students in high school exhibit stronger negative behaviours in both these regards [more depressed performance and greater mathematics avoidance]” (Hembree, 1990, p. 45). These results demonstrate the clear need for male students to also have supports. Hence, future studies should include a concerted effort to include male and/or non-binary populations.
In future work, an investigation into how contemplative practices can support marginalized students in the post-secondary mathematics classroom should be performed. According to Berila (2014), contemplative practices play a fundamental role in courses that deal with oppression or with marginalized students. Weger, Hooper, Meier, and Hopthrow (2012) discussed the stereotype threat in mathematics, or gaps in mathematics performance due to gender and ethnicity. They further investigated how mindfulness-based interventions may alleviate some of that gap in academic performance. This research does not delve into the concept of privilege and marginalization; however, the foundation it lays will lead to deeper, more innovative research done at the doctoral level. Beilock (2020) wrote that “research consistently shows that girls and women experience more math anxiety and are less confident in their math skills than boys and men are” (para. 22) and “studies on math performance across the US education system also indicate persistent—and widening—achievement gaps between white and minority students. This skills disparity is especially dire for black, Latinx and Indigenous students” (para. 23).

Moreover, further study on length and intervention type needs to be executed. For example, investigations relating to both short-term and long-term interventions need to be undertaken to determine whether longer-term interventions are truly required to affect positive change in math anxiety. Due to time commitments, if short-term interventions were successful, then they would be easier to incorporate into the lives of students. Furthermore, due to difficulties surrounding implementation and timetabling, perhaps including practices within a math course should also be examined.

Finally, future work investigating the relationship between math anxiety and math performance requires a multiple linear regression approach (Moore, McCabe & Craig, 2017, p.
In the Literature Review, it was demonstrated that between 7% (Ma, 1999; Hembree, 1990) and 11.5% (Namkung et al., 2019) of math performance is explained by math anxiety. Other factors, from skill deficits, to math avoidance, to working memory drops, to influences need to be incorporated to create a more detailed picture to better identify what is affecting math performance.

Evidently, there are many possibilities for future work, especially with the reward being so high – decreasing math anxiety. Mighton (2020) wrote that “math is the key to a better world” in the title of his new book. With less math anxiety, more people could unlock the possibilities to improve their own situations and lives.
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Appendices

Appendix A: The Five Facet Mindfulness Questionnaire

**Description:** This instrument is based on a factor analytic study of five independently developed mindfulness questionnaires. The analysis yielded five facets that appear to represent elements of mindfulness as it is currently conceptualized. The five facets are *observing*, *describing*, *acting with awareness*, *nonjudging of inner experience*, and *nonreactivity to inner experience*.

Please rate each of the statements on the following double-sided page using the scale provided. Write the number in the blank that best describes your own opinion of what is generally true for you.

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<th>never or very rarely true</th>
<th>rarely true</th>
<th>sometimes true</th>
<th>often true</th>
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1. When I’m walking, I deliberately notice the sensations of my body moving.
2. I’m good at finding words to describe my feelings.
3. I criticize myself for having irrational or inappropriate emotions.
4. I perceive my feelings and emotions without having to react to them.
5. When I do things, my mind wanders off and I’m easily distracted.
6. When I take a shower or bath, I stay alert to the sensations of water on my body.
7. I can easily put my beliefs, opinions, and expectations into words.
8. I don’t pay attention to what I’m doing because I’m daydreaming, worrying, or otherwise distracted.
9. I watch my feelings without getting lost in them.
10. I tell myself I shouldn’t be feeling the way I’m feeling.
11. I notice how foods and drinks affect my thoughts, bodily sensations, and emotions.
12. It’s hard for me to find the words to describe what I’m thinking.
13. I am easily distracted.
14. I believe some of my thoughts are abnormal or bad and I shouldn’t think that way.
15. I pay attention to sensations, such as the wind in my hair or sun on my face.
16. I have trouble thinking of the right words to express how I feel about things.
17. I make judgments about whether my thoughts are good or bad.
18. I find it difficult to stay focused on what’s happening in the present.
19. When I have distressing thoughts or images, I “step back” and am aware of the thought or image without getting taken over by it.
20. I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.
21. In difficult situations, I can pause without immediately reacting.

22. When I have a sensation in my body, it’s difficult for me to describe it because I can’t find the right words.

23. It seems I am “running on automatic” without much awareness of what I’m doing.

24. When I have distressing thoughts or images, I feel calm soon after.

25. I tell myself that I shouldn’t be thinking the way I’m thinking.

26. I notice the smells and aromas of things.

27. Even when I’m feeling terribly upset, I can find a way to put it into words.

28. I rush through activities without being really attentive to them.

29. When I have distressing thoughts or images I am able just to notice them without reacting.

30. I think some of my emotions are bad or inappropriate and I shouldn’t feel them.

31. I notice visual elements in art or nature, such as colors, shapes, textures, or patterns of light and shadow.

32. My natural tendency is to put my experiences into words.

33. When I have distressing thoughts or images, I just notice them and let them go.

34. I do jobs or tasks automatically without being aware of what I’m doing.

35. When I have distressing thoughts or images, I judge myself as good or bad, depending what the thought/image is about.

36. I pay attention to how my emotions affect my thoughts and behavior.

37. I can usually describe how I feel at the moment in considerable detail.

38. I find myself doing things without paying attention.

39. I disapprove of myself when I have irrational ideas.
Appendix B: The Focus Group Questions

1. Let’s discuss some of the contemplative practices that you were introduced to in the Mindful Math sessions:
   a. Did you recognize any of the practices? If so, which ones?
   b. Do you feel one practice helped more than others did when it comes to how you feel about math? If so, which one?
   c. Is there a practice that you see yourself continuing to use going forward?
   d. Is there a practice that you never want to do again?

2. If you met a person who felt anxious about math, would you recommend trying some of these practices?

3. Is there anything else that you would like to add?
Appendix C: The Semi-Structured Interview Questions

1. How did you feel when you registered for your math course?
2. How did you feel when you walked into class, on the first day of classes?
3. How did you feel during your most recent class?
4. For how long have you felt anxious or stressed about math?
5. Do you remember an event that changed how you felt about math? Would you mind sharing it?
6. Let’s discuss some of the contemplative practices that you were introduced to in the Mindful Math sessions:
   a. Did you recognize any of the practices? If so, which ones?
   b. Do you feel one practice helped more than others did when it comes to how you feel about math? If so, which one?
   c. Is there a practice that you see yourself continuing to use going forward?
   d. Is there a practice that you never want to do again?
7. If you met a person who felt anxious about math, would you recommend trying some of these practices?
8. Is there anything else that you would like to add?
Appendix D: The Practices

The transcripts of the practices used throughout the *Mindful Math* sessions are presented in this appendix, in alphabetical order.

The 5-4-3-2-1 Practice

The Loving-Kindness Practice

The Math Class Visualization

The Pause Practice

The Raisin Meditation

A Sitting Meditation
The 5-4-3-2-1 Practice Transcript

(Based on the Practice from the Smith, 2018)

The 5-4-3-2-1 practice helps to ground us in the present moment, when we begin to feel strong emotions rising.

Begin by taking three deep breaths.

5: Acknowledge five things you see around you. You can say them to yourself or write them down. It could be a pen, a friend, a spot on the wall. Anything that you see around you.

4: Acknowledge four things you can touch around you. It can be the desk, your chair, the ground, the paper. Anything that you can touch around you.

3: Acknowledge three things that you can hear. Focus, if you can, on things that you can hear outside your body. It can be the ticking of the clock, the ventilation system, the rustling of papers. Any sound in your environment.

2: Acknowledge two things that you can smell. It can be another student, the air from outside, a white board marker. Anything that you can smell around you.

1: Acknowledge one thing that you can taste. It can be toothpaste from this morning, coffee, tea or a recent snack. If you can’t taste anything, then think of your favourite thing to taste.

Now that you have examined your five sense, take three more deep breaths and slowly come back to the room.
The Loving-Kindness Practice Transcript

(Based on the Loving-Kindness audio file from Levitt, n.d.)

Start by taking a comfortable position and gently close your eyes or turn your gaze downward.

Bring full attention to this moment. Allow your mind to settle and bring attention to the breath.

As you inhale, pay attention to breathing in. As you exhale, pay attention to breathing out.

Keep breathing naturally, and relax the body.

Think of a person close to you. A person who makes you feel happy the moment you think of them. Imagine that person standing on your right side, sending you their love. Hear them saying to you:

*May you be happy, may you be healthy, may you be safe, may you be at peace.*

Feel the warm wishes and love coming from that person towards you. Keep breathing naturally.

Now bring to mind the same person or another person who cherishes you deeply. Imagine that person standing on your left side, sending you wishes for your wellness, for your health and happiness.

*May you be happy, may you be healthy, may you be safe, may you be at peace.*

Feel the kindness and warmth coming to you from that person.

Now imagine that you are surrounded on all sides by all the people who love you and have loved you. Picture all of your friends, loved ones, pets being near you. They are standing around you, sending you wishes for your happiness, well-being, and health.

*May you be happy, may you be healthy, may you be safe, may you be at peace.*

Bask in the warm wishes and love coming from all sides. You are filled, and overflowing with warmth and love.
If you feel comfortable, place your hand on your heart. Allow the love to flow freely through your body. Love and acceptance, kindness and compassion.

Now, say to yourself: *May I be happy, may I be healthy, may I be safe, may I be at peace.*

Each time you say the words, give them your full attention.

*May I be happy, may I be healthy, may I be safe, may I be at peace.*

Savour the meaning of each word, feel them, embody them.

Take three more deep breaths. When you are ready, continue to hold on to the warmth and the love, and slowly open your eyes.
Math Class Visualization Transcript

(Based on the Text Anxiety Visualization from Gilbert & Gilbert, n.d.)

Find an alert yet comfortable sitting position.

Take a few moments to bring attention to the body and breathe in the present moment.

Begin with three deep breaths.

If there are some areas where tension is building, imagine directing your breath, upon exhale, to that area. Imagine breathing in relaxation… and breathing out tension.

Inhale a feeling of relaxation and exhale all the tension. Feel your muscles relaxing with each breath.

Take a deep breath in… hold it gently… and let it out… Breathe in again… pause… and exhale fully. Breathe in. Pause… and Out… In Out.. In… Out…

Keep breathing naturally. With each breath, you become more and more relaxed.

If any anxious thoughts linger, acknowledge them, but don’t try to do anything with them.

Imagine feeling calm and relaxed, where your body feels relaxed and heavy.

Begin to imagine entering your math class. You feel motivated and want to do well.

Fully imagine this feeling and allow yourself to experience it completely.

Feel the desire to do well and the motivation. You are eager to do well.

Imagine walking calmly into your classroom and sitting down.

As you walk into the classroom, you say to yourself “When I get to my chair, I will just focus on the class, even if I am feeling some anxiety.”

See yourself sitting in the chair. Notice what is going on around you.
You hear other students shuffling in their seats. You feel the temperature of the classroom. Is it warm or cool? You feel the hard desk under you and the floor under your feet.

You feel your pen in your hand. You see the instructor. You feel a hint of anxiety rising.

You say to yourself “I know it’s my anxiety. I notice it’s there, but it’s not going to stop me from learning in this class.”

Now, the instructor writes on the board. Imagine scanning over what’s written, calmly and confidently. You discover that you already know some of it. You feel that you are understanding the rest.

You feel relaxed, happy. You say to yourself “I will continue to think calmly and not let my anxiety take over.”

Take a long slow breath in and let it all out. Your body is relaxed. Allow your mind to become calm. In this state of calm, you can concentrate on the class and see things clearly.

Imagine finding yourself at the end of class. You feel good and proud. You say to yourself, “I got through this without panicking. I didn’t let my anxiety take over.” Enjoy the feeling of success.

Now that you have finished this math class visualization, you are feeling more prepared for the process of entering a math classroom. You are confident that you will be able to manage your anxiety and focus on the material. You are calm, confident, and in control.

As this practice comes to a close, slowly wiggle your fingers and toes and feel yourself slowly come back to the room. Gently raise your gaze or open your eyes. Welcome back feeling calm, motivated, and confident.
The Pause Practice Transcript

(From the smartEducation Facilitator Manual, 2015, pp. 2-3)

Please stop whatever you are doing, including silencing your cell phones and putting papers and other materials under your chair.

Give yourself credit for making it here today and for giving this time to yourself.

Take three deep breaths at your own pace, filling the abdomen first and then the chest; on the exhale, letting the air out of the chest and then the belly.

You might envision filling and emptying a balloon or a vessel of water.

Notice any physical sensations that are present in your body.

These may include sensations of feet against the floor, hands in your lap, or body against the chair.

They may also include any areas of tightness or relaxation, particularly in the middle part of the body. There's no need to try to change anything you are feeling; this is just about noticing.

Notice if there are any emotions present with you in this moment.

Notice where your mind is. Are your thoughts racing, or is your mind calm? Are there thoughts you have brought in with you from your day, or some anticipation about this class? Just notice their presence without trying to get rid of them or change them, and without getting caught up in them.

Spend a few more moments sitting with an awareness of sensations, emotions, and thoughts, without needing to change anything. Can you be curious about what you notice without making judgments?
**The Raisin Meditation Transcript**

(From the smartEducation Facilitator Manual, 2015, pp. 12-15)

Pass around a bowl of raisins, and ask each participant to take one. Ask that they do not eat it.

We are going to approach this raisin as if we have never seen or tasted one before.

It might be helpful to imagine that you have grown up in a place that doesn’t have this type of thing.

Pick up the raisin, and hold it in your hand.

Notice how it looks, remembering that you are looking at it for the first time. You might want to turn it over, hold it at different angles, or hold it up to the light. Notice how it looks at each angle. (Notice, too, the process of seeing. What is seeing? Is there a physical sensation that accompanies seeing? Can you see without thinking? Are seeing and thinking the same, or are they different processes?)

Without going into a lengthy analysis, you might consider the background of this raisin, including the elements that went into making it and where it might have come from. (Can you imagine the people who planted and harvested the grapes? Their children? The truckers? Their families?)

Now, closing your eyes, bring all your attention to how the raisin feels in your hand and fingers. Roll it around, and feel its texture and weight. (The skin is the largest sense organ in the body. What can you learn about the raisin through this “sense door”? Does this information overlap with seeing or imagining, or is it totally discrete? How much do you know about your own mind and body?)

As you touch the raisin, be aware of any thoughts or emotions that might arise, including any thoughts of whether or not you like raisins. Simply noticing what comes up for you.
In a minute, I will ask you to bring the raisin up to your ear. Before you do this, see if you can notice the intention to move. By sending the message from the mind to the body before you move, you can sometimes feel that moment of leaning towards the action - the “about to” moment. Then see if you can move the arm slowly, with awareness.

Shifting all of your attention to the sense of hearing and, as you move the raisin between your fingers, see if you can discover anything about it through this “sense door.” (Raisins are not very talkative, so notice the sense experience as well. How does it work? Is it discrete, or does it overlap with other senses?)

Slowly moving the raisin to your nose, noticing the movement of your arm and hand as you do so. Bringing your full attention to how it smells and to the way in which you smell it. Is it pleasant or unpleasant? What is it like to smell the raisin? (Does this sense overlap with any other senses? Does it provide you with new information? How does it work? Where, exactly, do you experience smell? Can you smell on the out-breath?)

As slowly as you can, bringing the raisin to your lips, and notice how it feels against them. Also bringing awareness to any sense of anticipation, disgust, or other judgments regarding what you are doing.

Before you put it in your mouth, notice any anticipatory thoughts or sensations.

Place it on your tongue, but don’t chew yet! Noticing the sense of touch in this part of the body. Is the sense of touch here the same as in the fingertips? Also noticing if your mouth is beginning to water. (The texture of the raisin may change a little as it is moistened, but see how the sensitivity of the mouth compares to the fingers.

Though a little flavour may leak out, stay with the sense of touch if you can.)
Now, as slowly as you can, begin to chew the raisin, keeping it in your mouth, focusing all your attention on the sense of taste. See if you can locate where the sensation of taste is the strongest. Again, noticing if you have any judgments, emotions, or thoughts as you are slowly chewing the raisin, and then bringing your attention back to tasting. (Exploring both the experience of the raisin and the sense apparatus of tasting, following taste sensation to where it travels in the mouth, tongue or throat. What is tasting? Is tasting a discrete sense domain, or does it overlap with other senses?).

Noticing the impulse to swallow - how does it feel in your mouth and throat?

As you are ready, swallow the raisin, paying attention to how it feels and tastes as it goes down your throat.

Sitting a few moments with the experience of having just swallowed this raisin, and noticing if you feel one raisin more full.
A Sitting Meditation (Pausing for Anxiety) Transcript

(Based on the Pause audio file from Levitt, T., n.d.)

Start by taking a comfortable position.

Allows shoulders to fall away from the neck.

Today, we will explore the practice of pausing.

We practice pausing at stop lights, at the end of conversations. But when it comes to stress and anxiety, pausing is very difficult.

When emotion rushes through us, it can be all encompassing. Our instinct is to panic, run or push it away. Each time we do this, we are conditioning our response system. The more strongly we react to anxiety, the stronger the hold it has on us.

Our reactiveness can also colour or distort our thoughts and experiences, feeding into the cycle. Although, we can’t control our emotions, practicing mindfulness helps us to respond in a calmer, healthier way. It also allows us to recondition our tendencies. The key to this pausing practice is noticing the gap as anxiety arises. That window between when anxiety occurs and when we react.

If we can pause in that window, even for the slightest moment, before anxiety sweeps us away, we can be more mindful of our response to it. Most of the time, this gap is unrecognizable, since we react to anxiety so swiftly. So like anything else, pausing takes practice.

On that note, let’s begin today’s practice. … perhaps inviting a small smile to your lips. Take a few deep breaths. Inhaling deeply, releasing the breath slowly. With each breath you take, feel your whole body relax.

Concentrate all your attention on the breath, as you notice it flow in and out. A never-ending cycle of flow.
Each time a thought or an emotion arises, see if it is possible to pause for a moment. See if it is possible to recognizing it, without trying to control it. After the pause, bring your attention to the breath. Use the pause to acknowledge instead of reacting. Allow the breath to be your only focus.

When your mind wanders, gently refocus on the breath. When you find yourself focusing on negative thoughts or the same old anxieties, use the pause to break that loop. You aren’t trying to change your experience. Just don’t get swept away by them. Just pause and stay with the breath. Allow it to soothe the mind and body.

Pausing to breathe allows you to ask yourself. Are these thoughts true?

By pausing allows us to question the reality of our thoughts. Question these thoughts more objectively. May I be jumping to conclusions?

As you take your next breath, return your attention to the room around you. Focusing on any sounds that get your attention. Wiggle your fingers and toes. When you are ready, open your eyes.