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Practicing Positive Coping Strategies For Managing Math Anxiety In A Secondary Mathematics Classroom

Courtney Kathleen Smith-Nelson

PRACTICING POSITIVE COPING STRATEGIES FOR MANAGING MATH ANXIETY IN A SECONDARY MATHEMATICS CLASSROOM

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science in Education, Secondary Education

By

Courtney K. Smith-Nelson

July 2016

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Mathematics

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ABSTRACT

The purpose of this action research study was to explore student and teacher perceptions on the usefulness of teaching students to practice positive coping strategies for managing math anxiety in a high school International Baccalaureate mathematics classroom. This study used a reflective action research methodology in which students' math anxiety levels were assessed using Alexander and Martray's Abbreviated Mathematics Anxiety Rating Scale (1989). Students were then surveyed on their use of coping strategies for managing math anxiety, presented with a variety of positive coping strategies, and asked to rate each strategy on its perceived worth and the likelihood that they would continue to use the strategies in the future. A variety of open-ended and Likert scale questions were used, and the teacher-researcher maintained a reflective journal on how the lessons and strategies were received. In this study, a survey of 48 juniors and seniors in an International Baccalaureate mathematics course revealed that the majority of the students had experienced varying degrees of math anxiety, with 21% being highly math anxious. Nearly half of the participants reported either using negative coping strategies or not being aware of any coping strategies at all for handling math anxiety or academic stress. Almost all of the students reported that it was a valuable use of their time to talk about math anxiety and practice these strategies in class. The results of this study indicate that there is a need for mathematics educators to include a discussion of math anxiety and how to cope with it in their classrooms.

KEYWORDS: math anxiety, secondary mathematics, coping strategies, attitudes toward mathematics, A-MARS

This abstract is approved as to form and content

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CHAPTER I: INTRODUCTION TO THE STUDY

Small talk with strangers can be difficult for me as a mathematics teacher. "What do you do?" they will inevitably ask. When I say that I am a teacher, people usually respond positively: "Wow, that's great," "Good for you," and so on, followed by the natural extension of the question: "What do you teach?" I steel myself and say with a smile that I teach high school mathematics. The reaction to this statement is visible, immediate, and almost always the same: a widening of the eyes, a slight grimace or shudder, and then the flat "Oh. Wow, that's awful," or some variation thereof. I have had acquaintances at social events pale and back away slowly from me after learning about my chosen profession, as if at any moment I might whip out a quadratic equation and demand that they solve it. "I still have nightmares about math class," a cashier at a convenience store once told me as I paid for my items.

I wonder how many of these strangers and acquaintances had heard of the term math anxiety. Did any of them realize that the sweaty palms and hyperventilation that they experienced at the thought of taking a mathematics test is a real, well-researched, and all-too-common phenomenon that a majority of students in America will face at some point in their academic careers (Andrews & Brown, 2015)? Even if they could put a name to it, how many of them were ever taught how to cope with or minimize their anxious feelings?

I have seen students tremble and cry before, during, and after mathematics tests; I have seen them raise their hands to ask for help before even looking at a word problem; and I have heard them say that they skipped school because they just could not handle the

thought of Algebra or Geometry class that day. I am not the only mathematics teacher to have witnessed these and other displays of math anxiety and negative coping techniques, but addressing math anxiety in the classroom has never been a topic of discussion in any teacher education courses, professional development workshops, or faculty meetings in which I have participated. Math anxiety is a real problem that negatively impacts the academic and emotional well-being of a significant portion of students (Ashcraft, 2002; Feng, Suri, & Bell, 2014; Lefevre, Kulak, & Heymans, 1992; Park, Ramirez, & Beilock, 2014; Perry, 2004). Yet it seems, in my personal experience, that there is little being done about it in the classroom. Therein lies the fundamental inquiry of this study: what can be done to teach students to positively cope with math anxiety?

Rationale and Purpose of the Study

Math anxiety is the sum of the physical and emotional responses to negative experiences with or anticipation of failure in mathematics (Legg & Locker, 2009). While there is ample literature available on teacher-led classroom practices that may reduce or prevent math anxiety, there is limited research on how students should be presented with tools to be independently proactive in coping with math anxiety both in and out of the classroom. After all, a student has little to no control over the classroom climate in which she may find herself; while one can hope that all students will at some point have a positive mathematics experience with a teacher sensitive to the needs of the math-anxious, the reality is that this may not be the case. In the post-No Child Left Behind climate of standards-based grading, high-stakes testing, and the arguably over-legislation of the classroom, it appears to me that teachers sometimes find themselves in a position

of relatively low autonomy when it comes to what and how content is taught in their classrooms. Instead of relying on educators who may or may not be willing or able to accommodate for the needs of math-anxious students, it follows that these students should be individually equipped with tools to independently navigate, survive, and ideally thrive in their mathematics courses. Thus, this study explored what it means to teach high school students how to cope with math anxiety in meaningful, positive ways.

The purpose of this action research study was to explore the perceived usefulness of teaching students to practice positive individual coping strategies for math anxiety in the high school mathematics classroom. The following strategies have been shown in other research to have positive impacts on anxiety and performance: expressive writing; taking small "brain breaks"; physical relaxation training, especially in conjunction with systematic desensitization; emotional relaxation through humor; and specific environmental controls, such as listening to slow-tempo music immediately prior to or during mathematics performance situations.

Research Questions

This study was guided by the following research questions:

1. What strategies, if any, were students utilizing to manage math anxiety prior to any instruction about it, and how often were they using them?
2. What differences exist in the coping strategies used by students with higher levels of math anxiety compared to those with lower levels?
3. In what ways do students of all levels of math anxiety perceive the usefulness of learning positive strategies for coping with math anxiety after practicing these strategies in class?

4. Based on the teacher's perceptions of the impact of presenting positive coping strategies for managing math anxiety in the classroom, is there a place in the high school mathematics curriculum for teaching about math anxiety?

Action Research Design

The focus of this study was secondary mathematics students' perceptions of learning and practicing positive coping strategies for managing math anxiety. The participants were 48 of the 50 juniors and seniors in my International Baccalaureate (IB) Mathematical Studies course, and all of the activities pertaining to the study were carried out in my own classroom following the action research approach described by Gay, Mills, and Airasian (2009). I functioned in the role of teacher-researcher in order to achieve a deeper understanding of how to help my students to cope with math anxiety in the context of my specific classroom. In that respect, this study utilized a mixed-methods approach to action research in that both quantitative data (using Likert scale questionnaires and instruments) and qualitative data (open-ended questions and teacher-researcher reflections) were collected.

Prior to discussing math anxiety or coping strategies, students were given the Abbreviated Mathematics Anxiety Rating Scale (A-MARS) developed by Alexander and Martray (1989) in order to identify the participants with high and low levels of math anxiety. Students were also initially given questionnaires to determine their awareness of math anxiety (or academic anxiety in general) and their use of coping strategies prior to any discussion in class. Then, over the course of an academic quarter, students practiced, discussed, and reacted to six positive coping strategies as part of our daily classroom activities. Students provided feedback throughout the course of the study about their

perceptions of the usefulness of these strategies and whether they could see themselves using them in future mathematics classes. Student responses were summarized with percentages when applicable in quantitative questionnaire items (such as Likert scales) and open-ended questions were analyzed for common themes or key words. Additionally, the teacher-researcher's journals were used to reinforce, comment, or expand on the results of data collected from the students.

Significance of the Study

One of my goals as a mathematics educator is to make the study of mathematics more accessible to all of my students, regardless of (or better yet, in spite of) difficulty level or the students' prior experiences with mathematics. I have met so many students and parents who have settled into the mindset of "I am bad at math and that is just the way things are." In my experience, a certain number of students walk into my classroom every year fearing the subject and expecting failure before they have even opened a book or looked at a mathematical problem. In this way, math anxiety is paralyzing them and preventing them from seeing that mathematics is not some obscure, impossible subject mastered by only a select few, but something that is well within their reach to comprehend and use.

It is the ethical responsibility, then, of mathematics educators to address math anxiety in their students and help to mitigate its negative effects as much as possible. If adding explicit instruction in positive coping techniques is an effective way to alleviate or reduce the consequences of math anxiety, then perhaps a dialogue with educators,

students, parents, administrators, and legislators should occur in order to ensure best practices for mathematics education and the well-being of mathematics students.

Assumptions

The scope of this study was to explore practices to cope with or reduce math anxiety, not to prevent it; while prevention is ideal for any sort of negative physical or emotional condition, it is assumed that as long as the current culture of mathematics education exists, math anxiety will also continue to be a prevalent concern among students and teachers. Thus the practices researched, developed, and implemented in this study followed from the assumption that math anxiety is a more-or-less permanent fixture in the psyche of high school mathematics students that must be addressed from a treatment perspective, rather than one of prevention. In this sense also was the underlying assumption that the timing of this study is not conducive to a traditional "pre-post" approach that is often used to determine differences in achievement before and after the implementation of an intervention. The purpose of this study was not to measure differences in achievement (although other studies do exist that examine the relationship between math anxiety and academic achievement), but rather to determine whether students and their teacher found it worthwhile to practice strategies for managing math anxiety in the classroom.

There were also certain assumptions about the culture of the students being presented with the coping strategies. The literature review and chosen coping strategies were almost universally based on the traditional Western notion of stress, its symptoms, and how people react and cope with it. Similarly, it was not considered inappropriate or

in violation of social boundaries to discuss feelings of stress and how to manage them in the classroom, a norm that is not present in all cultures. Since the study was conducted in a Midwestern American high school, it was assumed that these particular norms will hold true for the vast majority, if not the entirety, of the participating students.

Limitations

The scope and timing of this study provided only a snapshot of one set of students' responses to and perceptions of learning positive coping strategies for math anxiety. Ideally, this particular topic could be more thoroughly researched through a longevity study to see if, after leaving the class in which they first learned the strategies, the students actually continued to incorporate the strategies into their study and homework habits. Additionally, such a longitudinal study could also examine whether use of these strategies could actually change a student's level of math anxiety in the long term, potentially progressing an individual from being highly math anxious to only moderately so, or a moderately math anxious individual to a low level of math anxiety. Since this study took place over the course of one academic quarter, it cannot be used to comment on any possible long-term effects of the interventions, but only the students' initial reactions and intent to use the strategies in the future.

At the beginning of the study, it was established that many of the participating students had not heard of math anxiety or knew very little about it, which required for me to lead a class discussion outlining the definition of math anxiety. Additionally, in order to assess students' levels of math anxiety, they had to respond to questions that asked about their level of anxiety in different situations involving mathematics, essentially

informing them of its "symptoms." In informing students about math anxiety and what it commonly looks like in students, there was the potential for the students to have been influenced to think that they experience it more than they really did, or to report an inaccurate level of math anxiety that was biased by the class's introduction to it.

As with any action research study, there were limitations to the statistical generalizability of the results. Purposive sampling of my own students, rather than random sampling, was used. Also, since the participants were my own students, I was aware of the possibility that they may have felt inclined to report more positive outcomes than what they were really experiencing in an effort to please their teacher. It was my goal in regards to this issue to make it clear to students that there was no grade or reward given for their feedback and that all data would remain confidential in order to limit this particular type of response.

Finally, the particular group of participants selected for this study were highly involved in extracurricular activities that caused daily class attendance rates to vary widely. Many of these students had perfect or nearly perfect attendance on paper, as they are not penalized for school-related absences, but when nearly every student in a class is involved in sports, drama, debate, or academic competitions (and most of them participate in more than one of these), it is difficult to predict how many students will be in class on any given day. Thus, the number of participating students was inconsistent throughout the study, since most of the activities that were done to practice positive coping strategies required students to be in class in order to participate.

Definition of Terms

The following terms are defined for the purposes of the study.

1. *Math anxiety*: feelings of "tension, apprehension, or fear that interfere with math performance" (Ashcraft, 2002, p. 181). Students with math anxiety often display physiological and emotional symptoms that are similar to stress or anxiety in general (Lyons & Beilock, 2012a).

2. *Coping strategy/technique/skill/intervention/method*: the terms "strategy," "skill," "technique," "intervention," and "method" are all synonyms in this context for the set of practices and behavioral or cognitive tools that were taught to high school mathematics students to help them positively manage and reduce math anxiety (Arem, 2010). A coping strategy is any practice, positive or negative, that an individual uses in an attempt to relieve or reduce stress or anxiety.

3. *Positive coping*: also called productive coping, this is the set of coping strategies that help an individual manage stress while still functioning or performing appropriately in a given situation (Turner, Meyer, Anderman, Midgley, Gheen, Kang, & Patrick, 2002).

4. *Negative coping*: the set of strategies that may reduce or relieve anxiety through actions that remove the individual from the stressful situation at the expense of productivity or performance, or that include other negative consequences (Turner et al., 2002). Examples of negative coping strategies for math anxiety include avoidance behaviors such as disrupting class to avoid doing mathematics or skipping class altogether.

5. *Systematic desensitization*: an anxiety reduction technique used by mental health professionals in which an individual is repeatedly exposed to a particular stressor in a controlled, nonthreatening environment until she is desensitized to it (Zettle, 2003). In this study, the stressor was the expectation of performing increasingly difficult mathematics tasks over the course of an academic quarter of a high school mathematics course.

6. *HMA and LMA students*: students who are considered to have high levels of math anxiety after taking the A-MARS instrument are referred to as HMA students. Similarly, students with low levels of math anxiety are referred to as LMA students.

Summary

The purpose of this action research study was to explore the perceived usefulness of teaching students to practice positive individual coping strategies for math anxiety in

the high school mathematics classroom. Math anxiety is a well-documented problem for a significant portion of high school and college students that can have detrimental effects to learning and performance. As a mathematics teacher, I believe that it is necessary to address the problem of math anxiety in my classroom and that by engaging my students in a discussion about how to positively cope with math anxiety, they may be better prepared for the mathematics courses that they will encounter in high school and college.

This study introduced positive coping strategies to secondary students with a variety of math anxiety levels as part of daily classroom activities in which students' levels of math anxiety were first identified. Students then practiced and responded to a series of positive coping strategies for managing math anxiety and rated these strategies on their perceived worth. The six positive coping practices used in this study were expressive writing, taking short brain breaks, relaxation techniques (mindful breathing and meditative coloring), and the strategic use of music and humor.

CHAPTER II: REVIEW OF RELATED LITERATURE

Math anxiety is the term given to feelings of fear, dread, or tension "associated with anxiety-provoking situations that involve interaction with math" (Legg & Locker, 2009, p. 471). Extensive research on math anxiety has been ongoing since the 1970s. In a meta-analysis of studies on math anxiety, Hembree (1990) concluded that math anxiety has a negative effect on school grades and test performance, and can cause students to avoid pursuing careers or university majors in fields of study that require knowledge of mathematics. In the years since Hembree's research, numerous studies have shown that math anxiety exists within and negatively effects various specific populations: nurses calculating drug dosages, high school and university students taking standardized tests, elementary teachers planning mathematics lessons, and adults managing shopping computations and financial planning, to name a few. Additionally, women and minority students have a higher risk of experiencing math anxiety than other populations and are more likely to avoid majors requiring greater quantities of mathematics courses (Ashcraft, 2002; Feng, Suri, & Bell, 2014; Lefevre, Kulak, & Heymans, 1992; Park, Ramirez, & Beilock, 2014; Perry, 2004).

It is estimated that anywhere from 25% to 80% of college students experience feelings of math anxiety at some point during their academic careers (Park et al., 2014), while Perry (2004) suggests 85% is a more accurate figure. Students tend to first experience math anxiety between the 6^{th} and 9^{th} grades, with levels of math anxiety gradually increasing through high school and college (Andrews & Brown, 2015). In other words, research suggests that the majority of the population has experienced or are

experiencing math anxiety, unfortunately to their academic, professional, and personal detriment. It is no surprise, then, that researchers have been pursuing methods and strategies for reducing feelings of math anxiety and its effects in the classroom.

Math Anxiety in the Context of Stress and Coping

There are multiple approaches to stress, fear, and anxiety that have been developed over the years in the field of psychology. Math anxiety is at its core a form of stress. Individuals suffering from anxiety or stress usually experience both psychological and physical symptoms (Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011). In assuming that math anxiety is experienced in much the same ways as other forms of stress or anxiety, this study uses the traditional paradigm of "fight or flight" reactions to stress as the framework about which the research will be conducted. The framework is as follows: an event or characteristic of an individual's environment is deemed by that individual to exceed his capacity for adapting or meeting the demands of the situation; should these demands be interpreted as threatening to his well-being in some way, the individual experiences a variety of emotional, physical, and behavioral responses in an attempt to either deal with or flee from the stressor in a fight or flight instinct (RAND, 1999). In the context of math anxiety, the perceived threat (the stressor) is the expectation to perform mathematical tasks that the individual believes may lead to failure, humiliation, ridicule, or some other negative social stigma.

Cohen, Ben-Zur, and Rosenfeld (2008) examined math (and in a more general sense, test) anxiety as a two-fold construct: the cognitive (i.e. the mental processes associated with the negative emotions) and the physical - specifically the arousal of the

autonomic nervous system. High levels of arousal in the autonomic nervous system are associated with the "fight or flight" response to fear, and physical symptoms such as heightened pulse, sweating, shaking, and temporary hearing loss. In fact, in a 2012 study, Lyons and Beilock (2012b) used magnetic resonance imaging (MRI) data to analyze neural reactions to the anticipation of being presented with a mathematics problem in students with varying levels of math anxiety. Participants were given a variety of mathematical and non-mathematical questions to answer ranging in levels of difficulty. However, before being shown a question, the participants were shown a cue card, indicating that the next question would either be a mathematical or non-mathematical item. Lyons and Beilock (2012b) discovered that in the time after being informed that a mathematical item was next but immediately prior to the item being presented, highly math-anxious students would experience activity in the dorso-posterior insula and mid-cingulate cortex of the brain, areas that are "implicated in pain perception" (p. 5). Additionally, when highly math-anxious students were cued that the next item was a non-mathematical question, the responses from these areas of the brain were diminished, which indicates a feeling of relief from pain; that is to say, the brains of highly math-anxious students may actually experience the anticipation of being asked to do a mathematical task as pain.

Physical reactions to negative emotions have also been linked to working memory, which is thought to be why math anxiety can have such a significant impact on mathematics performance, even among individuals who are competent in mathematics. Working memory is the short-term cognitive process that regulates focus and thought on a particular task at hand (Ashcraft & Kirk, 2001). Numerous studies have linked math

anxiety to a decrease in working memory functions (Ashcraft, 2002; Ganley & Vasilyeva, 2014); in particular, researchers found a link between the physical symptoms of a negative emotional response and a decrease in working memory in the context of math anxiety. Autonomic nervous system arousal in the context of doing mathematics problems was measured by the levels of cortisol in the saliva of math-anxious students who were asked to complete a mathematics test (an increased level of cortisol is another physical indicator of stress or anxiety). The researchers found that the more anxious participants had higher levels of cortisol in their saliva, and that these levels correlated to impaired working memory function during a mathematics assessment (Mattarella-Micke et al., 2011). This suggests that the anxiety itself is responsible for the negative impacts on mathematics performance, an explanation for which is proposed by Park, Ramirez, and Beilock (2014): math anxiety creates a "dual-task situation in which students must manage both intrusive thoughts [about their feelings of stress and anxiety] and the component processes…necessary for solving math problems" (p. 104). Math-anxious students, then, must grapple with their brains working twice as hard as their low-anxiety counterparts when presented with mathematics tasks.

Teaching Methods for Reducing Math Anxiety

There are many strategies and techniques for teachers to use in their classrooms that have been shown to be effective in decreasing math anxiety, one of which is letting students explore and acknowledge their math-anxious feelings through writing. Park et al. (2014) expressed concern with the notion that "less attention has been focused on the worry component of math anxiety" (p. 104). They discuss how instead of acknowledging

the "anxiety" part of math anxiety, educators focus on drilling mathematical skills to presumably increase mathematical competence. They designed a study to explore the effects of expressive writing on math-anxious students. After identifying participating college students as having either high or low levels of math anxiety, highly math-anxious students performed better on a computerized math test after 7 minutes of free writing about their thoughts and feelings about the upcoming mathematics test than their counterparts in the control group, who were asked to wait quietly immediately prior to the test. In addition, the achievement gaps between high and low math anxiety students was significantly diminished in the expressive writing group. Achievement was measured in relation to both the students' reaction times to particular mathematics items as well as their accuracy in answering those items. It should be noted that when the participants also took a "word problem" test that did not involve mathematics, there were no significant differences in achievement between the high and low math-anxious students in either the control or writing groups; that is to say, having students write specifically about math anxiety explicitly improved performance on a mathematics assessment, regardless of general test anxiety (Park et al., 2014, p. 109).

Similarly, Stogsdill (2013) developed what he called a "math therapy exercise" in which students in a math course journaled about the following six topics: "my earliest memory or memories of math; when and why math became difficult for me; my worst memory or memories of math; my best memory or memories of math; how I really feel about math; and how I really feel about taking this course" (p. 122). The students then shared their thoughts and feelings with the rest of the class in a group therapy-style discourse. These journaling and discussion exercises were meant to occur most frequently

at the beginning of a course and taper off as the course progressed. Stogsdill (2013) found that of the 132 students enrolled in his undergraduate mathematics course over two years, 128 of them had negative memories of mathematics. However, the vast majority of these students reported having significant reductions in math anxiety, especially when the journaling and discussion exercises were coupled with students writing supportive responses to each others' journal entries. While Stogsdill's study was more anecdotal than experimental, his results are supported by other researchers who include expressive writing and open discussions of feelings toward mathematics as viable and effective classroom practices to curb math anxiety (Furner & Duffy, 2002; Fotoples, 2000).

Even proponents of the more traditional perspectives on mathematics education - those who focus on content mastery rather than student feelings toward the content - are suggesting alternative classroom practices and procedures that can help to reduce math anxiety. While Fotoples (2000) contends that topic mastery and attention to differences in learning styles be addressed as the primary math anxiety reduction and prevention techniques, he acknowledges the importance of teacher sensitivity to students' feelings and reactions in the classroom. Furner and Duffy (2002) suggest increased use of cooperative learning, mathematical manipulatives, and technology as preventative to math anxiety in addition to a gentler approach to teaching mathematics; for example, it is suggested that teachers should avoid calling out students to answer a question on the spot in front of the rest of the class. The National Council for Teachers of Mathematics has included all of these in its prescribed best practices for teaching and learning mathematics since 2000 (NCTM, 2000). The fact that math anxiety continues to plague students of all ages indicates that these practices, while undoubtedly valuable for mathematics educators

and students alike in teaching and learning the content, are not in themselves sufficient for the treatment of math anxiety. This is supported by Sukran Tok's 2013 study of the Know-Want-Learn (K-W-L) approach to learning mathematics, in which 6th grade mathematics students were separated into classes that learned a unit of mathematics either using the K-W-L process during lessons or just being presented with the material using "traditional" methods. KW-L is not new, and most educators are familiar with it as a tool for teaching content; however, Tok (2013) found that while students in the K-W-L group showed higher levels of achievement and metacognition skills than the control group, the method of teaching had no impact on the levels of math anxiety among the students. Thus, in helping students to manage and ultimately reduce math anxiety, it is the "anxiety" rather than the "math" that should be the primary focus.

Student Strategies for Reducing Math Anxiety

While there are practices and techniques that educators can implement in their classrooms to help students with math anxiety feel more at ease in mathematics courses, math anxiety is ultimately a construct of mathematics students' own individual thoughts, feelings, experiences, and brain activity. When presented with a stressful situation, an individual must find a way to cope. According to Ader and Erktin (2010), "coping is the sum of responses that an individual uses to manage a stressful situation" (p. 313). A coping strategy can be either positive or negative; that is to say, it can be a productive, healthy approach to dealing with a stressful situation (such as exploring solutions to solving a problem or techniques to refocus one's attention) or it can be an avoidance approach that may ultimately harm the individual in some way (Ader & Erktin, 2010).

Considering this dichotomy of positive or negative coping strategies, math-anxious students should be encouraged to develop and practice positive coping skills in order to manage and reduce math anxiety while minimizing nonproductive avoidance strategies.

Since math anxiety is at its core an emotional response, it is suggested that the best practices for reducing math anxiety are those that encourage emotional control and allow students to refocus their energies (Lyons & Beilock, 2012a). In their 2008 study, Beeftink, ven Eerde, and Rutte (2008) found that taking small breaks when feeling "stuck" can actually increase creativity and sharpen problem-solving skills, but only when the breaks were taken when the participants were ready to have a break. Additionally, Hallowell (2012) encourages frequent "brain breaks" for students with ADHD and anxiety, where they can take a minute or two to stand or stretch near their desks. "Physical exercise, even for one minute, presses the reset button on the brain and refreshes students mentally" (p. 37). Brain breaks have been a ubiquitous part of my daily classroom activities for just that reason: students, especially those who struggle with mathematics, feel better and seem to think more clearly after taking a few moments away from the problem, standing up, stretching, and maybe getting a drink of water, then returning to the task at hand.

To address the physical effects of math anxiety, it is helpful to look at what research has been done for treating anxiety in general. In a meta-analysis of research on stress and coping strategies, Francesco, Mauro, Gianluca, and Enrico (2009) found that relaxation training is effective in reducing stress and anxiety in a wide variety of populations, including those who experience anxiety without being diagnosed with an anxiety disorder. The relaxation training to which they refer includes meditation,

muscular relaxation, mindfulness, and breathing techniques that induce a calmer state of decreased physical and emotional arousal. In addition, Zettle (2003) conducted a study in which students were given relaxation training and exposed to calming music while presented with mathematics tasks in order to systematically desensitize them to math. Performance on the mathematics tasks increased as students were able to make themselves relax while in the midst of the mathematics performance situation.

In a 2014 study, Feng, Suri, and Bell conducted an experiment in which groups of participants were asked to calculate discounts on given products in order to do comparison shopping. Groups performed these tasks in settings where either fast-tempo instrumental music was playing, slow-tempo instrumental music was playing, or no music at all was playing. Feng et al. (2014) found that not only were the participants in the slow-tempo music group more willing to attempt the calculations in order to comparison shop, they were also more likely to accurately calculate the discounts. In this particular study, no explicit definitions of "slow" and "fast" tempos were provided; however, it is commonly assumed that slow-tempo music is measured at 50-80 beats per minute (Cossar, 2013). In addition, Ford, Ford, Boxer, and Armstrong (2012) conducted a study in which students of varying levels of math anxiety were exposed to a humorous situation (that is, the students were shown a comic strip) immediately prior to taking a mathematics test. The results indicated that exposure to humor before taking a mathematics test reduced anxiety and thus improved mathematics performance.

Summary

Math anxiety is the sum of the physical and emotional responses to negative experiences with or anticipation of failure in mathematics. Multiple studies have found that a substantial portion of students will experience math anxiety at some point in their academic careers, and math anxiety can have a detrimental effect on performance of mathematical tasks (Park et al., 2014; Perry, 2004; Andrews & Brown, 2015). In fact, individuals with high levels of math anxiety experience the physical symptoms of arousal akin to the "fight or flight" reactions in the autonomic nervous system and may even experience pain at the anticipation of performing a mathematical task.

In order to focus more on the "anxiety" part of math anxiety, I posit that students should be presented with strategies to be proactive in coping with their math anxiety. Some strategies that have been shown in research to have positive impacts on anxiety and performance are: expressive writing, such as journaling or reflecting on one's thoughts and feelings prior to a mathematics performance situation; taking short brain breaks to refresh oneself while working in a stressful situation; physical relaxation training, especially in conjunction with systematic desensitization; emotional relaxation through humor; and specific environmental controls, such as listening to slow-tempo music immediately prior to or during mathematics performance situations.

CHAPTER III: METHODOLOGY

Action Research Design

This study was an exploration of positive coping strategies for managing math anxiety to be implemented with my own IB Mathematical Studies students, and was performed and examined with a reflective action research study. The A-MARS instrument (Alexander & Matray, 1989) was used to identify high and low math anxiety students; the strategies taught were six positive coping strategies that research has found to be effective at reducing stress and anxiety and that, with mindful practice, would ideally replace negative coping skills in math-anxious students. These six positive coping strategies were: 1) expressive writing, especially immediately prior to a situation requiring mathematics performance; 2) taking small brain breaks during stressful math performance situations; 3) a meditative activity to practices physical relaxation training and systematic desensitization; 4) mindful breathing; 5) emotional relaxation through humor; and 6) specific environmental controls, such as listening to slow-tempo music immediately prior to or during math performance situations.

These interventions chosen for the study were all examples of positive coping strategies that were intended to help relieve or reduce math anxiety. At the same time, these strategies needed to keep students engaged in mathematics tasks in which they were expected to perform with the intent that they would be less reluctant or anxious to perform mathematics tasks in the future. The IB Mathematical Studies students were chosen as the participants for this study because I felt that they were uniquely situated to benefit the most from these interventions. After the classroom interventions were

completed, the data was analyzed by summarizing the students' responses to each survey question and identifying common responses and themes in the open-ended responses, particularly of the high and low math anxiety students. I compared the common responses for many of the questions between these two groups. The students were never made aware of which group (if either) they had been categorized.

Data Collection Procedures

Prior to beginning the study, approval from the Missouri State University Institutional Review Board (IRB) was obtained (Appendix A). Additionally, a letter of informed consent was provided to each participant, which was signed either by the student themselves (for those who were 18 years of age) or their legal guardian (Appendix B). Each participant was first administered Alexander and Matray's 1989 Abbreviated Mathematics Anxiety Rating Scale (A-MARS), a condensed version of the original 98-item MARS assessment tool first developed by Richardson and Suinn in 1983 (Appendix C). This 25-item instrument has an internal reliability measure of 0.96, a test-retest reliability of 0.90, and a measure of validity of 0.92 correlation to the original MARS instrument. In this study, the A-MARS was used to identify those students with high levels of math anxiety and those with low levels by calculating the sum of the responses on a 1 to 5 scale. Then, I administered the pre-intervention questionnaire (Appendix D), which collected data about what strategies students were using to cope with math anxiety prior to any strategies being discussed in class. This questionnaire consisted of survey questions of my own design.

Over the course of one academic quarter (approximately two months) , daily lesson plans were altered to include instruction and practice for each of the six positive coping strategies chosen for helping to relieve or reduce math anxiety. Some of the strategies, such as those involving meditative exercises, were practiced over several class periods, while others like the use of slow-tempo music only required a single lesson or discussion.

Mindful breathing and systematic desensitization through meditative practices were implemented first; the Chapter 10 review document used a color-by-number activity in conjunction with mathematical tasks (Appendix E). Students were instructed to work on an item in the review, then find the corresponding answer on the drawing of the frog in order to color that portion of the picture in with the colored specified next to the question. The purpose of this was to give math-anxious students a relaxing, repetitive activity interspersed with the stressor of performing a mathematical task in order to decrease levels of anxiety. In this document, question 1 came from Barron's *IB Math Studies* exam review book (Bruner, 2014, p. 181); questions two through four were from the specimen papers for the IB Mathematical Studies papers 1 and 2 (these are the standardized tests that all IB Mathematical Studies students take at the end of the school year) (International Baccalaureate, 2014, paper 1 p. 14; paper 2 p. 3, & paper 2 p. 8). The drawing of the frog used in the color-by-number activity was my own creation.

The color-by-number activity was the last review activity prior to taking a unit exam; the next class period, when the students were to take the exam, they practiced deep breathing for two minutes immediately prior to me handing out the exam papers.

Afterwards, students gave feedback about the mindful breathing and meditative coloring strategies on the Unit 6 Post-Test Survey that I created (Appendix F).

The next strategy implemented was expressive writing. The writing activities given to students are found in Appendices G and H. The free-writing activity in Appendix G was given to students immediately prior to taking a shortened IB practice exam and was modeled after the writing exercise described in Park et al.'s 2014 study; the writing activity in Appendix H was an abbreviated version of Stogsdill's 2013 "math therapy exercise" (p. 122). This activity was similarly given to students before looking at practice IB exam items.

The final strategies that were practiced with supporting documents were listening to slow-tempo music and interspersing mathematical tasks with humor. It was my own standard classroom practice to have music playing when students are working independently or participating in classroom activities; however, I tend to play a variety of music with a variety of tempos. On this particular day, I played slow-tempo music while the students were working. Additionally, they read a short excerpt from Arem's *Conquering Math Anxiety* (2010, p. 103). With this text, I asked the participants to describe their own habits and preferences relating to sound and music while working on mathematics (see Appendix I for the full document). The exercise in using humor took place while students were asked to independently review the rules of basic probability before we began working on more difficult concepts (Appendix J). The review questions in this packet were from the Barron's *IB Math Studies* exam review book (Bruner, 2014, p. 79, 80, & 83) and Pearson's *Mathematical Studies Developed Specifically for the IB* textbook (Carrell & Wees, 2008, p. 294).

Throughout the quarter in which these strategies were presented, students also practiced taking short (around five minutes or so) brain breaks during class. I would allow one brain break per class period, and they usually occurred in the middle of the most mathematically-intense portion of the period. For example, I would suggest taking a brain break during a lecture after completing a particularly complex problem, but not necessarily when students were doing a small group activity or reviewing older content. These brain breaks did not have any associated documents to go with them, but the students' perceptions of their usefulness, as well as their reactions to the remaining strategies, were collected on the final questionnaire that I created (Appendix K).

Each strategy was presented as a mini-lesson within a given class period for each of the participating classes, then practiced with the accompanying in-class activity. It is the nature of the action research design to reflect on and revise interventions as needed; it was during this step in the process that I was mindful of how well the interventions were received by keeping daily journals of the data collection process and the lessons were adjusted accordingly for the next class. For example, I noted how in the first class in which the students practiced mindful breathing, the students felt awkward and laughed nervously the first time that we adjusted our posture and tried to regulate our breaths to be slower and deeper. By the time we had revisited the practice a few times throughout the class period, they were comfortable enough with it to practice without laughing. Because of their initial feelings, I made sure to address that potential reaction with the second class before we practiced it; I let them know that it is okay to laugh or feel awkward the first time through, but it would get easier the more we practiced it. Hearing that seemed to make them less inclined to feel uncomfortable when we started.

Throughout the implementation of the strategies, student data was also recorded through my own classroom observations. I maintained a reflective journal of my thoughts and observations about the implementation of and student reactions to each strategy. A sample journal entry is located in Appendix L. The student questionnaires focused on the students' perceptions of the usefulness of each of the five strategies that they were asked to practice and on the likelihood that they will implement these strategies in the future.

Site of the Study

The high school in which the study was completed was the oldest and largest of the five high schools in a mid-sized city in the Midwest. With a student body of nearly eighteen hundred, 52% of whom are on free or reduced lunch, it was also one of the most socioeconomically disadvantaged high schools in the area. It was the only high school in the city to have the International Baccalaureate (IB) Program, a rigorous college preparatory program that stresses a globally-minded and well-rounded education for those who participate. It also hosted a program for gifted middle school students who were ready to take high school-level courses. The city in which the school was located had a population of approximately 160,000 people, 88% of whom are White. Since this high school housed the school district's English Language Learner program, approximately 25% of the student body belonged to a racial or ethnic minority, which, while not appearing to be a significant portion of the population, was greater than that of the city as a whole.

The school had a total of about 100 teachers, ten of whom comprised the mathematics department. The mathematics curriculum in place was the same as all of the

high schools in the district with the exception of the IB courses. Students followed a pathway that included a level of Algebra 1 (both regular and accelerated courses were offered; a level of Geometry (three levels were offered: Geometry Concepts, Geometry, and Honors Geometry); a level of Algebra 2 (either regular or honors); and fourth-year mathematics courses (College Algebra, Trigonometry, and Calculus). There was also a course called "Foundations of Algebra" for those lower-level students who were not prepared for the rigors of Algebra 1. The school district required that students pass three math courses in order to graduate. In order to enroll in any IB mathematics course as a junior or senior, students had to have successfully completed Algebra 1, Geometry, and Algebra 2, ideally at the honors level.

Participants

Purposive sampling was used to select the study's participants, who were 48 of the 50 students that comprise the school's two IB Mathematical Studies sections, all of whom were juniors and seniors (two students did not consent to having their data used in the study). I taught both sections of this course. Of these 48 students, 28 students were junior-level females, 8 students were junior-level males, 7 students were senior-level females, and 5 students were senior-level males. Additionally, the racial demographics of the students were 36 White students and 12 non-White students (of these 12 students, 7 students were of Asian descent, 4 students were Hispanic, and 1 student was African-American). Students who participate in the IB program must take IB courses in literature, a foreign language of their choosing, at least one science course, at least one branch of social studies, a mathematics course, and then a "sixth subject," which was usually a

course in the arts. All of these courses were taken during the students' junior and senior years, and in addition to completing all of these courses, the students were expected to complete an internationally-moderated project and take international standardized IB exams for each subject (written by the IB organization headquartered in Switzerland), write an extended essay outside of any particular class's curriculum, and accumulate a set number of creativity, action, and service (CAS) hours.

Students chose one of three IB mathematics courses to take their junior and senior years of high school, and could not enroll in any of these courses until they had successfully completed Algebra 2 or Algebra 2 Honors: HL (higher level) Mathematics, a two-year course that included topics from Trigonometry, Statistics, and Calculus 1 and Calculus 2; SL (standard level), a two-year course that focused mostly on Trigonometry and Calculus 1; or SL Mathematical Studies, a one-year course that most closely resembled a survey of topics from College Algebra, Geometry, and some Trigonometry. I taught SL Mathematical Studies, and I was the only teacher for this course. The students taking IB Mathematical Studies were chosen as the participants because I felt that their unique academic situation made them the most likely candidates of my current students to possess both a variety of levels of math anxiety and the desire (and accompanying work ethic) to overcome it. I anticipated that the IB Mathematical Studies students would be the ideal population for studying math anxiety and presenting positive coping strategies for it, since the students who choose to take this course were generally highly motivated, academically-oriented students who had a history of struggling with or disliking mathematics, and thus had been recommended to take the lowest level of IB mathematics courses offered. For many of these students, they had maintained A and B

level grades in all of their high school courses with the exception of mathematics courses. This particular combination of academic ambition and struggles with mathematics made this population particularly susceptible to math anxiety, and were thus the best candidates for participating in the study.

However, since IB students were generally very driven to succeed and have so many additional requirements and expectations to meet in the program, daily class attendance rates may widely vary based on the time of year and what extracurricular activities were currently in season. Many of these students had perfect or nearly perfect attendance on paper, as they are not penalized for school-related absences, but when nearly every student in a class was involved in sports, drama, debate, or academic competitions (and most of them participated in more than one of these), it was difficult to predict how many students would be in class on any given day. When presenting the data collected for each in-class activity, the total number of participants *n* varied from 37 to 48 students based on the attendance during that time.

Data Analysis

Over the course of the academic quarter in which this study was conducted, students provided data in the form of open-ended written responses to questions, Likert scale and multiple-choice questions, and rankings of the strategies that were presented in class. Additionally, I maintained journals and made my own observations about how the strategies were received in class and the students' verbal (and sometimes nonverbal) responses in the classroom.

Student quantitative data was analyzed by compiling responses and reporting out percentages and frequencies for each response; responses to open-ended questions were grouped by common key words or themes. I then compared what the students' responses indicated to my own observations about how the presentation and practice of the strategies went in class.

Ethical Considerations

Prior to beginning the study, approval from the Missouri State University Institutional Review Board (IRB) was obtained (Appendix A). Additionally, a letter of informed consent was provided to each students participant, which was signed either by the student themselves (for those who were 18 years of age) or their legal guardian (Appendix B). The letter of consent was also provided in Spanish for those who requested it.

Considering the nature of the study, there were some aspects of the selected interventions that may be considered culturally insensitive or offensive to some students. For example, many popular breathing and relaxation techniques are based in yoga, which, being a traditional Eastern practice, has historically had a spiritual component that some practitioners of Western religions may deem immoral or inappropriate. To curtail this, the spiritual components of the interventions were not discussed in class; since the site of the study was a public school, it would be inappropriate to promote any religious practices.

Summary

Forty-eight IB Mathematical Studies students participated in this study, as they were deemed to be a population particularly susceptible to math anxiety, but would also have the motivation and work ethic to want to overcome it. Students were rated on their individual math anxiety levels through A-MARS tool; as the coping strategies were presented and practiced in class, students were asked to provide feedback in the form of questionnaires about their self-imposed coping strategies, perceptions of the worth and usefulness of the strategies presented in class, and their likelihood of continuing to use them in the future. Additionally, I kept records of my own observations in the form of journals. Data was analyzed specifically to compare the responses of students determined to be highly math-anxious to those identified as having low levels of math anxiety.

CHAPTER IV: RESULTS

Prior to any discussion of math anxiety or coping strategies, students were first administered the A-MARS instrument (Alexander & Martray, 1989) to identify the students with high levels of math anxiety and those with low levels (Appendix C). The questions in this survey were presented in a Likert scale where students were presented with various situations involving doing mathematics or taking a mathematics course, then asked to rate their level of anxiety. For example, the instrument asked students to rate their level of anxiety when "studying for a math test," "picking up a math textbook to begin working on a homework assignment," or "realizing you have to take a certain number of math classes to fulfill requirements" (Alexander & Martray, 1989, p. 1). The options for the levels of anxiety were "Not at all," "A little," "A fair amount," "Much," and "Very much." Assigning each response a number 1 through 5, where 1 indicates a "not at all" response and 5 a "very much" response, the participants' anxiety levels were represented as the sum of their responses from the 25 item instrument. So, for example, if a student responded "much" to the statement about studying for a math test, that response was recorded as a 4. The results of this instrument (n = 48) were that eight students had a raw score from 25-49 (mean score of 1-1.99), 30 had a raw score from 50-74 (mean score of 2-2.99), and 10 had a raw score of 75-99 (mean score 3-3.99). No participants had a score of 100 or above.

For the purpose of this investigation, I chose to define a participant who was "highly math-anxious" (HMA) as having a mean A-MARS score greater than or equal to three (in other words, those whose most frequently responded as experiencing "a fair

amount" of anxiety or more), and a participant who was "low math-anxious" (LMA) as having a mean A-MARS score less than two (meaning that their most common responses were "not at all" or "a little"). In this group of 48 students, there were 10 who met the criterion for being highly math-anxious. Of these ten individuals, three were male and seven were female. The mean raw score for all of the females (n = 35) was 62.8, while the mean raw score for all of the males (n = 13) was 57.5. A raw score of 62.8 indicates that the mean response on the instrument was 2.5 for females, and a raw score of 57.5 is a mean response of 2.3 for males; in other words, the "average" responses to items on this instrument were "a little" and "a fair amount," with males' typical responses skewing slightly more to "a little" than the females' responses.

Of the ten highly math-anxious students, only one student, a female, did not respond to the math anxiety self-rating on the final questionnaire (Appendix K) with "anxious most of the time" or "highly anxious pretty much any time I think about it." Conversely, of the eight students who were scored as being the least math anxious, only one, also female, did not respond to the same question on the final questionnaire with "rarely or never" or "not regularly" experiencing math anxiety. This indicates that the HMA and LMA students were overall aware of their anxiety level without being told; that is, they selected responses for rating their own level of math anxiety that were consistent with their results from the A-MAR (the totals, mean scores, and criteria for classifying high and low levels of math anxiety from the A-MAR were not shared with the participants). It should be noted also that the eight lowest-scoring participants on the A-MARS instrument were equally divided by gender, with four males and four females.

Research Question 1

In order to discuss what coping strategies the students were already using prior to the study, it was first necessary to assess what knowledge or awareness the students already had of math anxiety. Question 1 of the pre-intervention questionnaire (Appendix D) states, "Describe what you know or have heard about math anxiety." 15 out of the 48 participants (31%) reported knowing "very little" or "nothing" about it, while nearly the exact same amount (16 out of 48, exactly one-third) used words like "stress," "nervous," or "panic" to describe what they had heard about it. The remaining third of students either responded ambiguously (for example, one student wrote, "It affects women") or commented on how they knew several people who had experienced it in the past. One female student who was classified as neither HMA nor LMA responded with, "It feels like dying." These results are consistent with the results from questions 11 and 12 of the final questionnaire, "Before this class, I was aware of what math anxiety was," and "I often thought about math anxiety," respectively, with the response options of "Strongly Disagree" (SD), "Disagree" (D), "Neutral" (N), "Agree" (A), and "Strongly Agree" (SA). Table 1 shows the results of these questions.

Table 1. Responses to questions 11 and 12 from the final questionnaire regarding students' awareness of math anxiety (n = 38).

Question	SD[1]	D	N	A	SA
11. Before this class, I was aware of what math anxiety was.	3%	26%	8%	37%	26%
12. I often thought about math anxiety.	18%	18%	34%	11%	18%

[1] The possible responses to the questions were Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA).

The results from question 11 ("Before this class, I was aware of what math anxiety was.") indicate that while over half of the students were aware of math anxiety prior to the interventions, nearly a third were not aware; six of the ten HMA students selected "Agree" or "Strongly Agree" for this question, while two of the eight LMA students selected these options. The most common response to question 12 ("I often thought about math anxiety") was "neutral," with all of the other responses spread relatively uniformly across the other options. Five of the ten HMA students selected "Agree" or "Strongly Agree" for question 12, and none of the LMA students selected either of these responses.

Question 2 of the pre-intervention questionnaire (Appendix D) asks, "Do you think you have experienced math anxiety before?" It was during the time in class when students were to answer this question that we first discussed math anxiety, what it is, and what its symptoms are for those students who had not heard of it before. After a brief class discussion, 85% of the participants answered yes to this question. I observed that after a brief description of math anxiety, multiple students from both sections of the course appeared visibly excited or surprised; one student asked, "Why have none of our other math teachers ever talked about this?" Several students nodded in agreement with this statement.

Students were asked again to rate their own math anxiety level at the end of the interventions in the final questionnaire (Appendix K). Table 2 below shows each question and its results.

Table 2. Where would you place yourself on the spectrum of math anxiety? (n = 38).

Response option	Students' selection (%)
I rarely or never feel anxious about math	11%
I have sometimes felt anxious about math, but not too regularly	45%
I feel anxious about math most of the time, especially when I am preparing for a test.	34%
I feel highly anxious about math pretty much any time I think about it.	11%

All but four participants reported having experienced some math anxiety in their lives, with 45% selecting the two responses indicating a higher level of anxiety.

Question 4 of the pre-intervention questionnaire (Appendix D) asks, "What strategies do you currently use (if any) to deal with math and/or academic anxiety?" Fourteen of the 48 participants (29%) listed negative coping strategies such as procrastination, smoking, "ignoring the problem," or "crying" as their primary means of handling math or academic anxiety. They were not provided with any examples or prompts to describe positive or negative strategies in this question. Nineteen percent responded that they do not have any coping strategies that they use at all. As for positive coping strategies such as time management, mental breaks, and exercising, 19 out of 48 (40%) responded that these were their primary coping strategies. In the final questionnaire (Appendix K), questions 13 and 14 asked students to rate on a Likert scale their use of positive and negative coping strategies. The questions and the percentages of each response are found in Table 3 below.

Table 3. Students' use of coping strategies prior to intervention (n = 38).

Question	SD[1]	D	N	A	SA
13. I regularly used positive coping strategies to help regulate my stress and (specifically) math anxiety (like deep breathing, music, etc.)	8%	26%	34%	26%	5%
14. I regularly used negative coping strategies to avoid math (like "forgetting" to do homework, being "sick" on test days, etc.)	13%	45%	11%	24%	8%

[1] The possible responses to the questions were Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA).

Nearly the same percentages of students agreed or strongly agreed with regularly using positive coping strategies as negative coping strategies, while more students disagreed with the statement about using negative coping strategies than positive. This indicates that the students used a variety of coping strategies, but more students either chose to avoid negative strategies or chose to underreport their use of these strategies.

Participants were asked to respond to each of the interventions presented in class and to report if they had ever used them prior to their introduction in class. The Unit 6 post-test survey (Appendix F) asked participants about their experiences with deep breathing and the systematic desensitization (that I called "meditative coloring") practiced in class. The class practiced deep breathing exercises to regulate the physical symptoms of anxiety immediately prior to an assessment and a meditative coloring activity in which students interspersed practicing the mathematical content of the class with a relaxing coloring activity. Eighty-one percent of the 40 students who were present for the activity and questionnaire had heard of or used deep breathing exercises as a stress

management tool prior to practicing it in class, and exactly half of the students present for the activity had heard of or used coloring as a meditative practice to induce relaxation. It is interesting to note that of those who said that they used coloring in the past as a relaxation technique, only one of them was male.

After spending time listening to slow tempo music in class while going about normal classroom activities, students were asked to describe the sound conditions in which they prefer to learn and/or study (Appendix D). Out of the 38 participants who were present in class for the music intervention, 34 of them indicated that their preferred environment for studying involves listening to music or having some form of background noise. Of those four who did not prefer music, only one indicated that she works best in silence, while the other three responded as having no preference. However, half of the participating students selected the option "Slower music makes no difference in the level of comfort and focus." As a classroom teacher, I observe students doing nearly all of their daily school activities - working on a computer, going to their locker or the restroom, eating lunch - with earbuds in listening to music unless they are explicitly told not to do so. The results of the questionnaire about music do not come as a surprise; this generation is accustomed to having music available to them nearly everywhere they go, so it would be expected that nearly all of the students reported using music as a study tool or coping strategy without necessarily ascribing its effects to one particular tempo or type of music.

In the final questionnaire given after all of the interventions and activities were completed (Appendix K), question 2 stated, "In the past, I have tried to make myself laugh while doing math to help me relax." This statement was accompanied by a Likert scale from "Strongly Disagree" to "Strongly Agree." In responding to this question, 34%

of the students selected “Strongly Disagree,” 29% selected “Disagree,” 26% selected “Neutral,” 11% selected “Agree,” and 3% selected “Strongly Disagree” (n = 38). Humor, then, was not as widely used as deep breathing exercises or listening to music. Similarly, no students at all had used expressive writing as a coping strategy for math or academic anxiety prior to its presentation in class.

Question 8, also on the final questionnaire, is a Likert scale question that states, “In the past, I have made myself take short brain breaks while studying or doing homework.” Twenty-three of the 38 participants selected “Strongly Agree”; seven selected “Agree”; four were neutral; four selected “Disagree”; and no one selected “Strongly Disagree.” This indicates that the majority, but not all, of the students were already using the strategy of taking short breaks. However, students were not asked to describe the details of how they implement these short breaks; in my class, I would set a timer for five minutes when practicing this strategy, and students knew that when the alarm sounded, the break was over and it was time to resume work. I noted in my journal a discussion I remembered having with a parent of one of the participants earlier in the school year. The parent had come to me with concerns about her son’s stress level at home when doing homework, especially his mathematics homework, and asked if I could offer any advice. We discussed several strategies, one of which was taking short breaks, especially during lengthy study or homework sessions. She responded that her son would often try to do this, but would then get distracted by his phone or the television; what should have been a five-minute break would become half an hour of playing a game or texting. When discussing the use of breaks in class, one student did mention that it was helpful to set a timer “to make yourself come back to your work.”

Research Question 2

All ten of HMA students reported having experienced math anxiety in the past on the pre-intervention questionnaire (Appendix D), and when asked again at the end of the interventions to rate their anxiety, 9 out the 10 selected the responses indicating moderate to high levels of anxiety (Appendix K). On the other side of the spectrum, of the eight students LMA students, seven responded on the pre-intervention questionnaire that had experienced math anxiety at some point in their lives, but only one selected the moderate or higher level of anxiety options on the final questionnaire.

Question 4 of the pre-intervention questionnaire (Appendix D) asks, "What strategies do you currently use (if any) to deal with math and/or academic anxiety?" Seven of the ten HMA participants reported either not having any coping strategies all or using negative strategies like smoking, "crying," or procrastination. All three of the HMA students who reported using positive coping strategies specifically mentioned "breathing exercises." It should be noted that this question was asked of them prior to any of the interventions discussed in class. Along with asking students about their current use of coping strategies, they were asked to provide feedback about each individual coping strategy that was discussed and practiced in class. The Unit 6 post-test survey asked participants about their experiences with the systematic desensitization techniques practiced in class. Nine of the ten HMA participants and five of the eight LMA participants had heard of or used deep breathing exercises as a stress management tool prior to practicing it in class; two of the ten HMA and three of the eight LMA participants had heard of or used coloring as a meditative practice to induce relaxation.

All of the HMA students reported preferring music or noise for their studying conditions; the one participant in the whole group who reported preferring silence was an LMA student. When asked on the final questionnaire about using humor as a coping strategy prior to practicing it in class, only one HMA and one LMA student each selected the "Agree" response, with all others either selecting the "Neutral" or "Disagree." All of the LMA and HMA participants reported using brain breaks prior to our discussing and practicing it in class.

Table 4 below compares the HMA students' responses about their preferences for the strategies to the LMA students' responses, as well as their reported likelihood of using these strategies in the future. The responses about the deep breathing and meditative coloring strategies came from the post-test survey, questions 3 and 7, respectively (Appendix F). The responses to listening to music came from the last question on the music questionnaire (Appendix I), and the responses to the use of humor, brain breaks, and whether the students plan on using any of these strategies in future math classes came from questions 3, 7, and 19 of the final questionnaire (Appendix K).

Table 4 shows that HMA students responded more positively than LMA students, while LMA students were more likely to respond neutrally to a strategy than HMA students. The one exception for both of these statements is in the case of music. The question that was asked was, "Do you think listening to slower music on a regular basis in class or while you are doing math work could be beneficial for you?" As discussed, while only one student reported not regularly listening to music while studying or doing homework, most students either did not have a preference of tempo or preferred faster

music to keep them alert, which would explain the negative and neutral responses recorded for music in the table.

Table 4. Comparing responses of high math anxiety (HMA) and low math anxiety (LMA) students.

Coping Strategy	HMA (n = 10)	LMA (n = 8)
Deep Breathing	Positive: 8 Neutral: 1 Negative: 1	Positive: 4 Neutral: 2 Negative: 2
Brain Breaks	Positive: 7 Neutral: 3 Negative: 0	Positive: 4 Neutral: 4 Negative: 0
Meditative Coloring	Positive: 8 Neutral: 1 Negative: 1	Positive: 4 Neutral: 3 Negative: 1
Music	Positive: 4 Neutral: 2 Negative: 4	Positive: 4 Neutral: 2 Negative: 2
Humor	Positive: 4 Neutral: 4 Negative: 2	Positive: 2 Neutral: 6 Negative: 0
Future Use of any Strategy	Positive: 7 Neutral: 3 Negative: 0	Positive: 1 Neutral: 7 Negative: 0

The most striking result is that of the question, "I plan on using some or all of these strategies as I study math in the future," where seven of the ten HMA students responded positively and none responded negatively, while only one LMA student responded positively and the rest responded neutrally. The shows that the HMA students

most likely felt that learning about positive coping strategies for math anxiety was a worthwhile use of their time, much more so than LMA students.

Research Question 3

Question 5 of the pre-intervention questionnaire (Appendix D) asks, "Do you think it would be helpful to learn strategies for managing academic anxiety? Why or why not?" Forty-three of the 48 participants responded yes; several of the HMA participants commented that they felt a significant need for learning about how to manage stress and anxiety, and three LMA participants said that even if they did not often experience math anxiety, it would be worthwhile to spend time in class practicing and learning these strategies for the others who do.

Students were asked about the worth and usefulness of each strategy presented in class. Question 3 of the Unit 6 post-test questionnaire (Appendix F) states, "Do you think it was helpful or worthwhile to take the time in class to talk about deep breathing exercises?" to which 29 of the 38 (76%) who were present for the activity responded positively. Additionally, 20 of the 38 students (53%) reported in question 4 on the post-test questionnaire that practicing the deep breathing exercises immediately prior to taking the unit exam helped them to calm down and better focus. From question 5 of the same document, 28 of the 38 (74%) intended to continue using deep breathing as a coping strategy in the future. Four of the nine who responded negatively to question 4 about the usefulness of practicing deep breathing prior to taking the exam were HMA students, and one was an LMA student. One of the negative responses to question 5 relating to continuing to use deep breathing as a coping strategy in the future was an HMA student,

and two were LMA students. Question 7 of the post-test questionnaire asked about both the perceived usefulness of and the desire to continue practicing meditation through coloring while working on math. Twenty-nine of the 38 present participants responded positively to both parts of the question. Of the nine who indicated that they did not find it useful and/or would not like to continue doing it in class, one was an HMA student, one was an LMA student, and the remaining seven were in the middle group.

Thirty-eight students were present for the music intervention. On the questionnaire regarding music and sound level (Appendix I), 26 (68%) indicated that listening to slow music could be beneficial while studying mathematics. The difference between these results and those discussed in research question 1 is primarily due to several students commenting that they prefer faster music when studying or that the slower music caused them to feel sleepy and less motivated. Five of the ten HMA and two of the eight LMA participants responded negatively to listening to slow music in class, preferring music with faster tempos.

In the final questionnaire (Appendix K), questions 3 and 4 asked about the perceived usefulness of humor and the students' intentions of using it in the future as an anxiety management tool. The results are displayed in Table 5 below. The results of these questions indicate that this strategy was not as well-liked as some of the others, and fewer students responded as being likely to use this strategy in the future. Additionally, questions 7 and 9 of the final questionnaire pertained to the use of brain breaks while studying; the results are displayed in Table 5 below.

Table 5. Students' responses to using humor and brain breaks (n = 38).

Question	SD[1]	D	N	A	SA
3. Having humorous asides on the probability review helped me to feel better about the material.	3%	8%	29%	53%	8%
4. I intend to use humor to ease my tension or academic stress in the future.	11%	5%	32%	39%	13%
7. Brain breaks help me refocus my attention and energy to math.	0%	3%	5%	34%	58%
9. I intend to make short brain breaks a habit while I am studying or doing homework in the future.	0%	3%	11%	18%	68%

[1] The possible responses to the questions were Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA).

Note how only two participants responded negatively to the use of brain breaks in class; of all of the strategies discussed in this study, this particular one had the most positive responses, and more students indicated that they intend to use this strategy in the future. It should be noted, though, that this strategy was also the one used most frequently by students prior to any discussion of it in class, so it follows that more students would indicate that they intend to use it in the future. However, this does show that practicing the structured, carefully timed breaks in class did not seem to cause students to want to stop using this strategy.

The final questionnaire also asked about the reactions and takeaways that students had overall, rather than just for individual strategies. Participants were asked to rank each strategy that was presented in order of how useful they felt each was, with a rank of 1

being the most useful and 5 being the least useful. Table 6 below shows the percentages of the students' rankings for each strategy.

Table 6. Students' ranking of coping strategies, from 1 (most useful) to 5 (least useful).

Strategy	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
Brain breaks	62%	18%	13%	5%	2%
Deep breathing	18%	28%	15%	28%	10%
Meditative coloring	5%	25%	21%	28%	21%
Expressive writing	10%	8%	2%	26%	54%
Humor	5%	21%	49%	13%	13%

Listening to music was not included in this ranking since the vast majority of students already utilized it when studying anyway (with the exception of the one participant who preferred silence). It should be noted that expressive writing had the lowest ranking for the majority of the students. When asked to comment on the strategies, some students wrote that writing about their anxious feelings immediately before doing practice IB exam items actually made them feel more anxious and stressed about the exam. Additionally, question 16 on the final questionnaire states, "The activities and strategies that we have done in this class for coping with math anxiety were worth taking the time and effort to do them." All but two of the present participants responded with either "Agree" or "Strongly Agree." The two who did not respond as such chose "Neutral."

Research Question 4

The results of the research questions discussed above, when paired with my own observations and the open-ended responses of the students, ultimately lead to the conclusion that there could be some value in teaching students about math anxiety in their mathematics courses, particularly, it would appear, in Geometry and Algebra 2 at the high school level. When first asking the participants to report if they have ever experienced math anxiety, 9 of the 48 (19%) specifically mentioned Geometry as the first course in which they experienced frequent math anxiety, 7 (15%) mentioned Algebra 2, and 7 reported that their math anxiety started in elementary or middle school. Additionally, in the expressive writing activities, the participants were asked to recount their best and worst memories of mathematics, and to also finish the sentence, "If math were a person, he/she would be…" These prompts were the same that Stogsdill (2013) used in his research and the responses that the students wrote were in many ways similar to Stogsdill's results: more negative responses about mathematics than positive, students relating specific memories that first "traumatized" them in mathematics, with early memories being more positive than later ones. For their best memory of mathematics, 19 participants (40%) recounted a memory from elementary school, 7 (15%) mentioned middle school, and 6 (12.5%) said either that they did not have a best memory of mathematics or that their best memory was the end of a mathematics course, meaning they would not have to do it for the summer. Of the remaining third, many of those responses did not specify an age or grade level. Only 6 students specifically mentioned a high school mathematics course or an experience in their high school careers that would be their best mathematics memory. For the worst memory of mathematics, 17 (35%)

reported that their worst memory of mathematics came from high school Geometry, 10 (21%) specifically mentioned Algebra 2 or Trigonometry, 12 (25%) mentioned some memory involving a mathematics test, and only 2 participants specifically mentioned a memory that occurred before high school.

The last writing prompt was, "If math were a person, he/she would be…" The following are a few of the responses that students wrote:

- "A demanding person who wants attention."
- "A controlling spouse." (Three students specifically used the word "controlling")
- "An annoying person that makes you feel bad about yourself." (three students specifically used the word "annoying," three made some reference to the "math person" making other people feel badly about themselves, and two students referred to the "math person" as being someone that nobody likes or who would have no friends.)

Of the 45 students who participated in this activity, 24 (53%) used words or phrases with negative connotations as in the examples above (and sometimes more colorful - one student wrote "If math were a person, he/she would be Satan."), four used words or phrases with positive connotations (for example, "math would be like a hipster - math is cool, people just don't realize it."), and the rest used neutral words or phrases, like "a complex individual."

Another aspect of the issue of math anxiety is that of ignorance of what mathematics courses are expected of students beyond high school. I noted in my journal that multiple students (particularly seniors) commented, "I wish I had known about this [strategy] sooner. This is my last math class ever, so I won't have to worry about it anymore." But is that really the case? On the final questionnaire (Appendix K), students were asked to list their intended majors when they reach university, and whether they

anticipated taking any higher level mathematics courses. The results indicate that these students may not be entirely aware of how much mathematics their planned major or career path will require. As participants in the IB program, all of these students are expected to be university bound, and as juniors and seniors, I had assumed that they were in the process of educating themselves on what their college and career choices would require of them. When asked, "What do you think your major in college will be?" and "Do you anticipate taking any higher math courses in college?", only four participants responded that they did not know what their major would be. Of those who did list a specific major (31 students in total, the remaining three did not respond to the questions), 7 wrote that they did not anticipate taking any further mathematics courses when their preferred major was a field that very explicitly requires some (or in a few cases, a lot) of mathematics. For example, one student said that he plans on studying engineering, but does not anticipate taking any higher mathematics courses in college. Another reported wanting to study neurobiology but also did not anticipate taking higher mathematics courses. That is nearly a quarter the participants, all IB, university-bound juniors and seniors, who do not appear to be aware that science and engineering majors require higher level mathematics. Do these results imply that mathematics educators should be more aggressive in their "pitch" for why mathematics education is a necessary part of university and career preparation?

Ultimately, though, the data that drives home the answer to this question and to the study as a whole, that math anxiety should be explicitly discussed and positive coping strategies presented to students in their mathematics courses, was the student input and classroom atmosphere that was present during the course of this study. By the end of the

quarter in which they were practicing the positive coping strategies, students would walk in asking what "math anxiety stuff" we were going to do that day, and more than one student thanked me for acknowledging in my class that math anxiety is a real issue that needs to be addressed.

On the first day that I introduced my research topic to my classes, more than one student exclaimed, "Oh my god, I didn't know there was a name for that!" Another said, "I just thought it meant that I was bad at math," even though her grade point average and test scores would certainly indicate otherwise. When I informed them that I was specifically going to spend time in class helping them to practice positive coping techniques for math anxiety, the response was vocal, widespread, and overwhelmingly positive. I wrote in my observations, "Some [of the students] almost looked relieved."

Summary

The results for research question 1 indicate that almost a third of the participants had not heard of or had very little knowledge regarding math anxiety, but once the concept was introduced to them, the majority reported having experienced it to varying degrees (although there is certainly a risk for bias here, that learning about it could perhaps cause students to believe that they had it). Nearly half (48%) reported either using no strategies at all for coping with math anxiety or academic stress in general, or used negative strategies such as procrastination. Of the interventions that were discussed and practiced in class, listening to music and taking small breaks while studying were the most commonly used positive coping strategies prior to the class activities.

For research question 2, the data for the HMA and LMA students indicated that the majority of HMA participants responded that prior to learning about positive coping strategies, they used negative coping strategies or none at all ("crying" was the response recorded from three of the ten HMA students). Similar proportions of LMA and HMA students reported regularly using or not using each of the specific strategies discussed in class. After the strategies were presented, HMA students responded more positively to the strategies than LMA students, and the majority of the HMA students reported that they intend to use these strategies in future mathematics classes.

The results for research question 3 indicate that taking brain breaks was by far considered to be the most useful strategy and expressive writing the least useful strategy after introduction and practice in class. The qualitative data that was collected illustrate that, per research question 4, there is in fact a place for teaching students about math anxiety in the high school mathematics classroom, given that the majority of the participants communicated a negative view of mathematics, particularly from Geometry and Algebra 2. Students responded positively and came to look forward to the lessons and activities about math anxiety and positive coping strategies.

CHAPTER V: DISCUSSION

Outcomes

The results of this study indicate that there is a need for addressing math anxiety and positive coping strategies in the mathematics classroom. Nearly a third of the students involved as a whole were unaware of the existence of or how to address math anxiety prior to class introduction and practice, and the reported use of negative coping strategies like procrastination was quite high prior to the interventions; almost half (48%) of the students reported using negative coping strategies. Some students listed both positive and negative strategies when asked what they do to manage their anxiety. For example, one student wrote that she would listen to music while working, but also would let herself be distracted by Netflix. Of the six specific strategies presented and practiced in class, taking short brain breaks and doing deep breathing exercises were considered to be the most useful and worthwhile, and were the two strategies that the participants reported being most likely to continue practicing in the future, particularly the HMA students. The participants ranked the expressive writing activities as the least effective, with some students commenting that expressing the negative feelings about math right before taking a test actually made them feel more anxious. These activities were helpful for the research, as they provided valuable insight into the students' attitudes toward mathematics and when their math anxiety began.

In conducting this study, it was my aim to also address the wider implications of this research by considering the culminating question: is there a place in the high school mathematics curriculum for teaching about math anxiety? In other words, based on the

research questions of this study, it was my aim to begin a dialogue about whether positive coping techniques for math anxiety should be included in any given student's mathematics education as a matter of course. It was my expectation that the interventions used in this research would promote positive experiences and outcomes for math-anxious students as they learned to cope with and overcome their anxiety. To summarize the results: the participants – IB Mathematical Studies juniors and seniors – already practiced some positive techniques for coping with math anxiety, but more either use negative coping strategies or none at all. The participants who were identified as highly math anxious were no more likely to already be practicing positive coping techniques prior to the interventions. Overwhelmingly, though, the HMA students, LMA students, and those somewhere in the middle all reported that it was worthwhile and useful to discuss math anxiety and practice strategies for minimizing it in the classroom. This indicates that there are potential benefits for secondary mathematics teachers to address math anxiety in the classroom, attending not only to the "math" part, but to the "anxiety" part as well.

Implications and Recommendations

What do these results say about high school students' perceptions of mathematics education? What does this say about our system of teaching mathematics to students, that the majority of these students experienced their best mathematics memory in elementary school, their worst in high school, and a third of the participating students - without being prompted to mention a specific time frame or course - said that high school mathematics was the catalyst for their math anxiety? While a certain amount of the negative perceptions of high school versus elementary school can be accounted for by the natural

increase in adult responsibilities and less childish coddling (for example, several students mentioned that they had an ice cream party as a reward for memorizing their multiplication tables, something that is not as plausible to occur at the high school level, especially in college preparatory courses), I posit that anxiety and dread are not natural side effects of a well-rounded and effective higher level mathematics education, and that an educational culture in which math anxiety is such a common phenomenon as to be taken for granted is doing a disservice to students and teachers alike. While it is beyond the purpose and scope of this study to even approach what changes should be made to the approaches to teaching mathematics, it remains a troubling state of affairs that the results of this study indicate that strategies for coping with math anxiety are in demand and should potentially be explicitly taught in the mathematics classroom along with the course content.

There is the potential for future research in this topic, especially through a longitudinal study, which was simply not possible for the scope and duration of this study. But my results here do raise some questions with potentially significant answers: could the long-term practice of positive coping strategies for math anxiety actually reduce math anxiety in HMA students? Could the practice of these strategies actually lead to a change in not only emotional state and attitude toward mathematics, but a change in achievement as well? Could a more in-depth look at when students first start having negative experiences and feelings about mathematics unearth a deeper cause or, more importantly, a "cure"? Is math anxiety itself the cause of this unease and what prompts the need for stress reduction and coping strategies, or is it a symptom of an underlying issue within the teaching and learning of mathematics?

Summary

The results of this study indicate that there is a need for mathematics educators to include a discussion of math anxiety and how to cope with it in their classrooms. The participating students were nearly unanimous in reporting that it was a valuable use of their time to talk about math anxiety and practice these strategies in class. The students rated deep breathing exercises and taking short 'brain breaks' as the most useful and what they would be most likely to practice in the future. Additionally, fewer than 10% of the participants, when prompted, described the subject of mathematics with positive verbiage. These results indicate that there are potentially problems with the culture of secondary mathematics that need to be addressed on a wider scale than the scope of this study to change the prevalence of math anxiety and negative attitudes towards learning mathematics.

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APPENDICES

Appendix A. Human Subjects IRB Approval

To: Gay Ragan

Mathematics

901 S National Ave Springfield MO 65897-0027

From: MSU IRB

Date: 1/25/2016

RE: Notice of IRB Exemption

Exemption Category: 1.Educational setting

Study #: 16-0260

Study Title: Teaching High School Students Positive Coping Strategies for Managing Math Anxiety

This submission has been reviewed by the Missouri State University IRB and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b).

Investigator's Responsibilities:

If your study protocol changes in such a way that exempt status would no longer apply, you should contact the above IRB before making the changes.

CC:

Courtney Smith-Nelson, Mathematics

Appendix B. Letter of Informed Consent

Consent to Participate in a Research Study
Missouri State University
College of Natural and Applied Sciences

Courtney Smith-Nelson

You (or your child) have been asked to participate in a research study as part of my requirements for a Master's of Science degree in Education. Before you agree to participate in this study, it is important that you read and understand the following explanation for the study and the procedures involved.

The purpose of this study is to investigate the effectiveness of teaching students strategies for positively coping with math anxiety as part of daily classroom activities in high school math classes. I will be demonstrating and asking students to practice using a variety of positive coping strategies for stress and anxiety in class such as expressive writing and mindful meditative practices.

If you (or your child) participate in this research, I will be writing about the results of surveys and questionnaires given throughout the semester that relate to math anxiety and the participant's thoughts and feelings about the coping strategies that were presented. The activities and lessons will be the same for all students, both participants and non-participants. This will include each student being asked to take a Math Anxiety Rating Scale at the beginning of the semester.

There are no foreseeable risks or discomforts to you (or your child) as the participant.

Your participation in the research is strictly voluntary. You may refuse to participate, or choose to stop your participation at any point during the study without fear of penalty or negative consequence.

The information/data that you (or your child) provide for this research will be treated confidentially, and all data will be kept in a secured file by the researcher, as is always the case with student information. Results of the research will be reported as aggregate summary data only, and no individually identifiable information will be presented.

You also have the right to review the results of the research if you wish to do so. A copy of the results may be obtained by contacting:

Gay Ragan – (XXX) XXX-XXXX, XXX@XXX.XXX (Thesis Advisor)
Courtney Smith-Nelson – (XXX) XXX-XXXX, XXX@XXX.XXX (Thesis Researcher)

Participant consent

I, (print full name), _____, the guardian of _____, have read and understand the information provided explaining the purpose of this research and my rights and responsibilities as a subject. My signature below designates my consent for my child to participate in this research, according to the terms and conditions listed above.

Signature: _____
Date: _____

Appendix C. A-MARS Instrument

(Alexander & Martray, 1989)

ABBREVIATED MATHEMATICS ANXIETY RATING SCALE (A-MARS) QUESTIONNAIRE

Please indicate the level of your anxiety in the following situations. Please choose ONE box on each line.

		Not at all	A little	A fair amount	Much	Very much
1.	Studying for a math test.	☐	☐	☐	☐	☐
2.	Taking math section of the college entrance exam.	☐	☐	☐	☐	☐
3.	Taking an exam (quiz) in a math course.	☐	☐	☐	☐	☐
4.	Taking an exam (final) in a math course.	☐	☐	☐	☐	☐
5.	Picking up math textbook to begin working on a homework assignment.	☐	☐	☐	☐	☐
6.	Being given homework assignments of many difficult problems that are due the next class meeting.	☐	☐	☐	☐	☐
7.	Thinking about an upcoming math test 1 week before.	☐	☐	☐	☐	☐
8.	Thinking about an upcoming math test 1 day before.	☐	☐	☐	☐	☐
9.	Thinking about an upcoming math test 1 hour before.	☐	☐	☐	☐	☐
10.	Realizing you have to take a certain number of math classes to fulfill requirements.	☐	☐	☐	☐	☐
11.	Picking up math textbook to begin a difficult	☐	☐	☐	☐	☐

	reading assignment.					
12.	Receiving your final math grade in the mail.	☐	☐	☐	☐	☐
13.	Opening a math or stat book and seeing a page full of problems.	☐	☐	☐	☐	☐
14.	Getting ready to study for a math test.	☐	☐	☐	☐	☐
15.	Being given a "pop" quiz in a math class.	☐	☐	☐	☐	☐
16.	Reading a cash register receipt after your purchase.	☐	☐	☐	☐	☐
17.	Being given a set of numerical problems involving addition to solve on paper.	☐	☐	☐	☐	☐
18.	Being given a set of subtraction problems to solve.	☐	☐	☐	☐	☐
19.	Being given a set of multiplication problems to solve.	☐	☐	☐	☐	☐
20.	Being given a set of division problems to solve.	☐	☐	☐	☐	☐
21.	Buying a math textbook.	☐	☐	☐	☐	☐
22.	Watching a teacher work on an algebraic equation on the blackboard.	☐	☐	☐	☐	☐
23.	Signing up for a math course.	☐	☐	☐	☐	☐
24.	Listening to another student explain a math formula.	☐	☐	☐	☐	☐
25.	Walking into a math class.	☐	☐	☐	☐	☐

Appendix D. Pre-Intervention Questionnaire

This questionnaire, like all of the data that I will be collecting, will be kept anonymous and confidential at all times. Please only identify yourself by your student ID number above.
Please answer the following questions as thoroughly and honestly as you can. There are no "right" or "wrong" answers, but please try to write at least two full sentences for each question (but more is always welcome if you have a lot to share!)

*Note: A "coping strategy" is any behavior that is meant to alleviate negative physical or emotional responses to stress. These strategies can be "positive" (like giving yourself a pep talk to keep yourself motivated) or "negative" (like avoiding asking for help so you won't have to admit that you are struggling).

1. Describe what you know or have heard about math anxiety.

2. Do you think that you have experienced math anxiety before? If yes, when and/or where? What kinds of situations have caused you to feel this anxiety?

3. Have you ever been taught any ways to cope with academic anxiety? If yes, what are some strategies that you have heard of before?

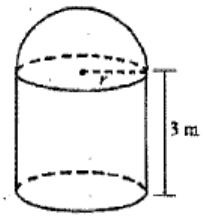
4. What strategies do you currently use (if any) to help deal with math and/or academic anxiety?

5. Do you think it would be helpful to learn strategies for managing academic anxiety? Why or why not?

Appendix E. Chapter 10 Review

Math Studies: Color By Number Review – Chapter 10 Name: _____

1. A water storage tank is constructed by a cylinder topped with a hemisphere. The height of the cylinder is 3 meters. The unit can hold 46.1 cubic meters of water when full.

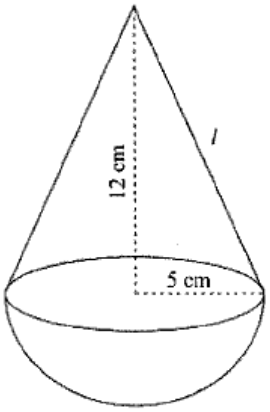


Blue a. Calculate the length of the radius, r, rounded to the nearest meter.

Purple b. Determine the surface area of the entire storage tank.

2. A child's toy consists of a hemisphere with a right circular cone on top. The height of the cone is 12 cm and the radius of its base is 5 cm. The toy is painted red.

diagram not to scale



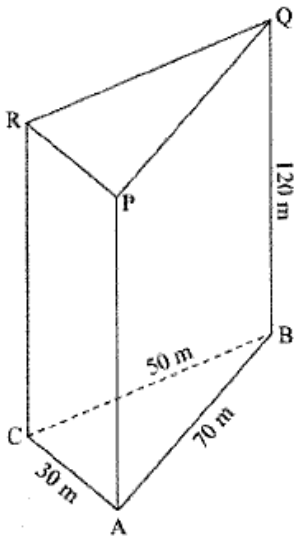
Yellow (a) Calculate the length, l, of the slant height of the cone.

Pink (b) Calculate the area that is painted red.

3. *[Maximum mark: 12]*

An office block, ABCPQR, is built in the shape of a triangular prism with its "footprint", ABC, on horizontal ground. $AB = 70\text{ m}$, $BC = 50\text{ m}$ and $AC = 30\text{ m}$. The vertical height of the office block is 120 m.

diagram not to scale



Light Green (a) Calculate the size of angle ACB. *[3 marks]*

Yellow (b) Calculate the area of the building's footprint, ABC. *[3 marks]*

Orange (c) Calculate the volume of the office block. *[2 marks]*

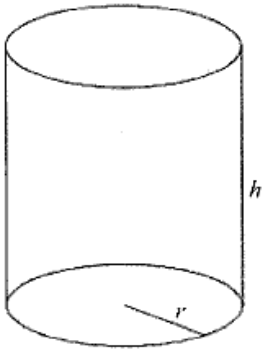
To stabilize the structure, a steel beam must be made that runs from point C to point Q.

Purple (d) Calculate the length of CQ. *[2 marks]*

Black (e) Calculate the angle CQ makes with BC. *[2 marks]*

4. Nadia designs a wastepaper bin made in the shape of an **open** cylinder with a volume of 8000 cm^3.

diagram not to scale



Nadia decides to make the radius, r, of the bin 5 cm.

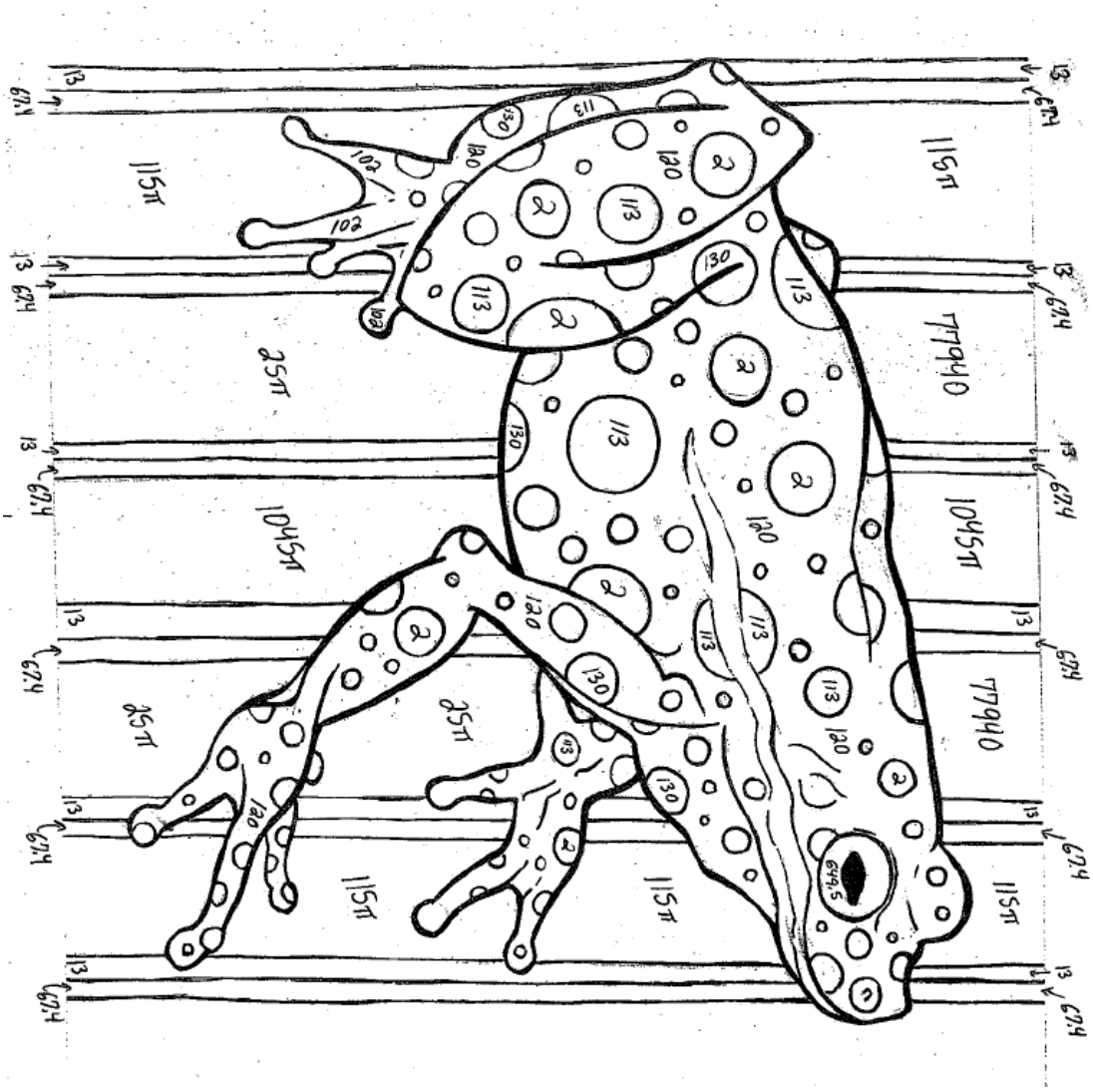
(a) Calculate

Orange (i) the area of the base of the wastepaper bin;

Light Blue (ii) the height, h, of Nadia's wastepaper bin;

(iii) the total **external** surface area of the wastepaper bin. *[7 marks]*

Pink (b) State whether Nadia's design is practical. Give a reason. *[2 marks]*


115π
25π
104.5π
25π
115π
115π
104.5π
77.940
77.940
115π
6945
120
130
113
102
103
111
2
1
13
67.4

Appendix F. Math Studies Post-Test Survey

Math Studies Post-Test Survey: Unit 6

1. (a) Did you feel prepared for this test? (b) Did you feel that the content on the test matched what we practiced in class?

2. Had you ever heard of and/or used deep breathing practices for managing anxiety **before** we talked about them in class? If yes, how often do you do it?

3. Do you think it was helpful or worthwhile to take the time in class to talk about deep breathing exercises?

4. Did practicing the deep breathing exercises before the test help you to calm down and/or focus better on your test?

5. How likely are you to practice deep breathing exercises to manage your anxiety in the future (of this class or just in general)?

6. Have you used "meditative coloring" to help you de-stress before?

7. Do you think it was helpful to have the opportunity to do "meditative coloring" in class? If yes, would you like to continue practicing it in class?

Appendix G. Free Writing Activity

Before you work on the IB exam items, we are going to take 3 minutes to do some free writing in which I want you to respond to the following question as honestly and thoroughly as possible. Don't worry about writing conventions – lists of words or phrases are acceptable. Just get the thoughts in your head on paper.

We are almost to the point of taking the IB Math Studies exam: what are your expectations for this exam? How do you feel (emotionally and physically) when you think about taking the Math Studies IB exam?

Remember: there are no "right" or "wrong" answers here. I am not looking for any particular type of response. Just be honest!

Appendix H. Questions about Mathematics

What is your earliest memory of math?	What is your best memory of math?
What is your worst memory of math?	Finish the sentence: If math were a person, it would be…

Appendix I. Excerpt from *Overcoming Math Anxiety* by Cynthia A. Arem (2010)

Excerpt from *Overcoming Math Anxiety* by Cynthia A. Arem

Sound Level

Do you like to study in a very quiet place, free from all distractions? For most people, this increases comprehension and the ability to figure out difficult problems.

Francine preferred silence and was easily disturbed by any sounds, particularly when she was nervous about an upcoming math test. She found wearing small moldable earplugs, which she bought at a local pharmacy, did the trick. She wore them every time she studied at home or in the library. Her concentration and retention levels increased markedly.

Other students find silence especially helpful when they work on demanding or problematic assignments, but they prefer some background music or noise when they do a routine or boring assignment or when they recopy notes.

Still others find, when it's too quiet, they become "hyperaware" of all sounds. Howard, an accounting major, always studies with the television or radio on in the next room, although he doesn't listen to it. If it's too quiet, he hears the refrigerator motor, the ticking of the living room clock, and the sounds of his own heartbeat.

Harriet, a statistics student, found playing soft, inspiring music increased her motivation for studying and the amount of material she covered. Tony, a calculus student, learns best when listening to music of classical baroque composers. The slow tempo of approximately one beat per second calms him and clears his mind.

EXERCISE 7-4 How Does Sound Affect You?

Briefly describe which sound conditions work best for you when you study math.

We listen to music fairly regularly in class. Do you prefer this, or do you prefer classes that work without music?

Today, we listened to music at a slower tempo than what we normally do. Did this slower music:
(choose one)

- □ Help you focus better and/or work more comfortably than faster music
- □ Distract you from the work
- □ Make no difference in your level of focus or comfort
- □ Other: _____

Do you think listening to slower music on a regular basis in class or while you are doing math work could be beneficial for you?

Appendix J. Reviewing Basic Probability

Reviewing Basic Probability (you know, before we get to the weird stuff…)

Most people have experienced humor or laughter relieving tension or helping a "heavy" situation to feel less intense (like when people laugh at startle jumps in a scary movie or make jokes at a funeral).

Not only can laughing make you feel better, research has shown that being exposed to humor immediately before or during a stressful academic task can actually increase students' learning and performance on that task!

With that in mind…

1) Reviewing basic probability:

$$P(A) = \frac{numbers\ of\ outcomes\ in\ A}{total\ number\ of\ outcomes}$$

The sample space contains all the possible outcomes of an event. For example, if a coin is flipped, the sample space would be heads (H) or tails (T). If a die is rolled, the sample space would be 1, 2, 3, 4, 5, or 6.

Example 1: Joe has a bag containing 5 red marbles, 7 blue marbles, and 3 yellow marbles. He reaches in and randomly selects one marble. What is the probability Joe selects:

A) A red marble?
B) A yellow marble?
C) A marble that is not blue?

12. When someone is taking too long to take a picture and you start overthinking how smiling naturally works.

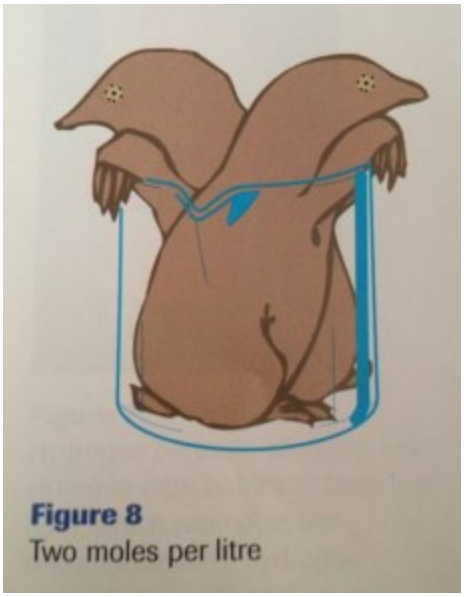


Figure 8
Two moles per litre

D)A green marble?

Example 2: You are interested in what students are eating for lunch in the school cafeteria. For one week, you record the choices of 100 students. The results are displayed in the table below:

Selected Food	Number of Students
Pizza	21
Salad	15
Hot Dog	16
French Fries	28
Fresh Fruit	20

A)Use the given information to find the probability that a student chosen at random:

a. Selected pizza
b. Selected fresh fruit
c. Did not select a hot dog
d. If 350 students are randomly sampled, how many students would you expect to select French fries?

Example 3: A local dog breeder has 50 small dogs. Twenty of the small dogs have brown hair and 30 have long hair. If 15 of the small dogs have long and brown hair, calculate the probability that a randomly selected dog has:

A. Brown or long hair
B. Long hair
C. Short and brown hair
D. Neither brown hair nor long hair

Example 4:

16. The following data was collected in a parking lot. If a car is selected at random, find each probability.

	General Motors	Hyundai	Porsche
Silver	15	10	10
Green	25	20	5

a) The car was silver or a Porsche.
b) The car was not a Hyundai.
c) The car was not green and a General Motors.

Example 5:

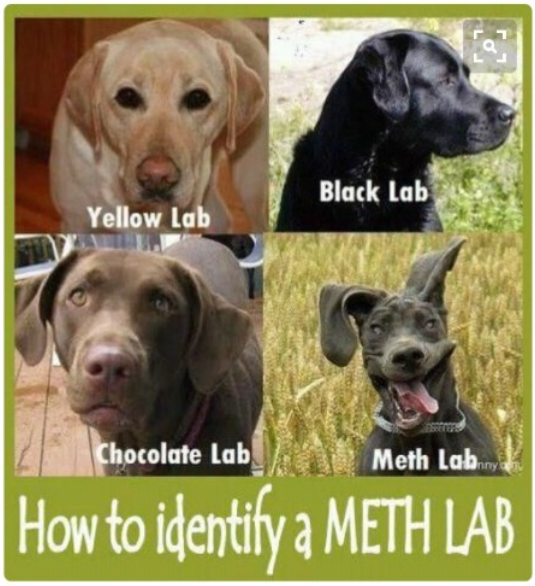
15. Data was collected for which gender reads which type of book. A book was selected at random. Find the probability that:

a) The book was read by a female or it was an action book.

b) The book was a historical book or it was read by a male.

c) The book was not read by a male and it was an action book.

	Action	Romance	Historical
Male	10	17	8
Female	3	4	8



Appendix K. Final Questionnaire

One Last Questionnaire about Coping with Math Anxiety

SA = Strongly Agree A = Agree N = Neutral D = Disagree SD = Strongly Disagree

Statement	SD	D	N	A	SA
1. Laughing helps to relieve my tension and stress.					
2. In the past, I have tried to make myself while doing math to help me relax.					
3. Having humorous asides on the probability review helped me feel better about learning the material.					
4. I intend to use humor to ease my tension or academic stress in the future (for example, by taking a break during math homework to watch a funny video, then going back to work).					
5. Do you have any additional comments to add about the humor activity?					
6. I like taking short "brain breaks" during class.					
7. Brain breaks help me refocus my attention and energy to math.					
8. In the past, I have made myself take short brain breaks while studying or doing homework.					
9. I intend to make taking short brain breaks a habit while I am studying or doing homework in the future.					
10. Do you have any additional comments about the brain breaks that we take in class?					
For items 11 through 14, think about your feelings, thoughts, and habits from **PAST MATH CLASSES.**					
11. Before this class, I was aware of what math anxiety is.					
12. I often thought about math anxiety.					
13. I regularly used positive coping strategies to help regulate my stress and (specifically) math anxiety (like deep breathing, music, etc.).					
14. I regularly used negative coping strategies to avoid math (like "forgetting" to do homework, being "sick" on test days, etc.)					
For items 15 through 18, think about **this math class** and the strategies and activities that we have done over the last few weeks. Remember, we practiced deep breathing, meditative coloring (the frog!), expressive writing before doing practice IB exam items, interspersing humor with probability review, and taking regular brain breaks in class.					

15. I have overall enjoyed the activities that we have done in class to practice coping strategies for math anxiety.					
16. The activities and strategies we have done in this class for coping with math anxiety were worth taking the time and effort to do them.					
17A. I would like to continue practicing these activities in class for the remainder of the school year (more breathing and/or writing before a test, coloring, brain breaks in class, etc.)					
17B. Which strategies in particular would you like to continue, if any?					
18. Please rank the activities and strategies that we practiced based on how useful you felt each was, with 1 being the MOST useful and 5 being the LEAST useful. Brain breaks _____ Deep breathing _____ Coloring _____ Expressive writing _____ Humor _____					
Future math classes...	**SD**	**D**	**N**	**A**	**SA**
19. I plan on using some or all of these strategies as I study math in the future.					
20. Using these strategies when I study math in the future may help me enjoy math more than I have in the past.					
21. Using these strategies may make me less intimidated by the possibility taking higher-level math in college.					

A few wrap-up questions:

Where would you place yourself on the spectrum of math anxiety? (Think of your overall history with math)

- ☐ I rarely or never feel anxious about math.
- ☐ I have sometimes felt anxious about math, but not too regularly.
- ☐ I feel anxious about math most of the time, especially when I am preparing for a test.
- ☐ I feel highly anxious about math pretty much any time I think about it.

Would you be willing to be interviewed about your particular level of math anxiety and your coping strategies?

☐ YES ☐ NO, THANKS

Would you be interested in attending a math anxiety/test anxiety "support group" where students could learn in more depth about academic anxiety and strategies for coping with it, if the school were to offer it?

☐ YES ☐ NO, THANKS

What do you think your major in college will be?

Do you anticipate taking any higher math courses in college?

Appendix L. Sample Journal Entry

Strategy practiced: Deep breathing and brain breaks

Observations: The first section to do deep breathing took a little bit of time to settle down. Had to talk to a student after she had a small outburst at another student for annoying her when we were doing the first round of breathing. Lots of uncomfortable laughing the first couple of times. Got less awkward as we kept practicing it. I modeled and practiced with them, and I definitely felt better afterward. Students were less chatty after, and most of them appeared to finish their homework quiz quicker than what it usually takes. When I asked them how they felt, most nodded and one said, "It kind of made me sleepy."

Later in class, when we finished a section of notes, one student said, "I think it's time for a brain break now," and several others agreed, so we took five minutes to get up, stretch, and get water. Only 5 or 6 students remained seated for this break, but they used it to check their phones.

Changes for the next lesson? Students seemed uncomfortable and laughed the first couple of times we practiced breathing as a group – should address with next class before starting. Also, spread out breathing practice – do some before the homework quiz then again at the end of class.