Reducing Math Anxiety in the Secondary Classroom

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Abstract (150-250 words)

It is a common experience to hear the words "I hate math," "I am bad at math," and other phrases with similar meanings. Math anxiety involves feelings of apprehension and tension when presented with a mathematical problem in all contexts whether it be at school or in ordinary life (Hopko et al., 2003b; Ashcraft & Moore, 2009). Math anxiety is common in students today. But, as the National Council of Teachers of Mathematics [NCTM] states "[e]xpectations must be raised – mathematics can and must be learned by *all* students" (p. 13). This paper explores factors that cause math anxiety (timed tests, instructional methods, teachers' attitudes, students' attitudes, and materials) so that teachers in the secondary classroom may avoid them. Along with, methods to reduce math anxiety (expressing feelings, anxiety management techniques, students' attitudes, instructional methods, bibliotherapy, and teachers' attitudes) for secondary mathematics teachers to implement into their classroom ordered from most to least effective. Secondary mathematics teachers are a part of students' crucial time of their lives where they decide their future pathways. By reducing their math anxiety, teachers are increasing the number of pathways the students may pursue. Also, secondary teachers can shed a better light on the subject of mathematics, so there are less people whose first response is "I hate math," but instead "I like math."

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Chapter 1

Introduction

When people learn this author is majoring in Mathematics Education they typically respond with: "why would you do that to yourself?", "more power to you. I hate math", "that sucks for you", "you're crazy." Too many people, in the author's opinion, have horrible experiences with mathematics and those memories make lasting impressions. Jackson and Leffingwell (1999) pointed out the negative memories caused by math anxiety are so "profound that mathematics anxiety could persist for twenty or more years" (p. 585). "People with untreated math anxiety experience the anxiety in a never-ending cycle of fear, confusion, and defeat" (Shodahl & Diers, 1984, p. 32). According to Jackson and Leffingwell (1999) only seven percent of their sample size had positive experiences with mathematics from kindergarten through college (p. 583). People with math anxiety quickly categorize themselves under the common myth that they are "not number people" or they do not have a "mathematical mind." These situations happen nearly every day. But with the correct methods to reduce math anxiety, the author can envision a day in our future where people are not afraid of mathematics or numbers, but embrace them and their full potential using them. Mathematics teachers, like the author's future self, are responsible for changing the way mathematics is viewed, so when the subject is brought up people do not shut down. We are responsible for changing the high number of negative experiences with mathematics to positive experiences. "An understanding of the nature and origin of math anxiety is crucial in interrupting this cycle, removing the emotional block, and allowing any math potential that may be present to actualize itself" (Shodahl & Diers, 1984, p. 32).

The author would ideally like to teach upper level high school mathematics classes which explains the choice to research methods of reducing math anxiety in the secondary classrooms. This topic was chosen because of personal experiences tutoring and observing mathematics classrooms in practicums, how mathematics is perceived, the lack of research synthesizing the different methods, and the results from using the different methods.

Addressing math anxiety in high school is important because at that stage in a student's life he/she thinks there is no hope, but there can be. Crippled by math anxiety "millions of adults are blocked from professional and personal opportunities because they fear or perform poorly in mathematics" (Tobias, 1993, p. 9). High school students should be looking at their future possibilities rather than their future impossibilities. If the teacher would be able to reduce their math anxiety it opens more doors to them in higher education and career options. The National Council of Teachers of Mathematics [NCTM] also realizes the importance of students learning and understanding mathematics. In Principles and Standards for School Mathematics (2000) NCTM states "We live in a time of extraordinary and accelerating change… The need to understand and be able to use mathematics in everyday life and in the work place has never been greater and will continue to increase" (p. 4). So much of the world revolves around mathematics and without that knowledge students will be dependent on others to make sense of the world for them. Too many teachers choose to pass over students with math anxiety, also believing there is no hope for them, but there is. Hembree (1990) took 10,428 measurements of students from sixth grade to postsecondary and found that the peak of math anxiety occurs in ninth and tenth grades (p. 41). It is a critical time for the students because it may be when they take their last math class. Students who have math anxiety tend to avoid future mathematics classes (Hembree, 1990, p. 38). But, if their math anxiety can be reduced, we can increase course taking which will

then improve the quantitative literacy in our country. The author wants to educate teachers of the upper grades about the most effective strategies of how to reduce math anxiety at one of the most pivotal moments in students' lives. "Mathematical competence opens doors to productive futures. A lack of mathematical competence keeps those doors closed" (NCTM, 2000, p. 5). With those strategies we can shed a better light on the subject of mathematics and enhance the educational and career opportunities for students.

As a future mathematics teacher, the author will need to have methods to reduce math anxiety, but which ones are the best? What are the research-based methods for reducing math anxiety? Of the identified methods, which are most effective? Research has been done on math anxiety for many years going back to the 1970's. The purpose of this inquiry study is to report the methods for reducing math anxiety in a high school setting and if they are effective.

This paper will define what math anxiety is, what possible causes of math anxiety are, and what the research-based methods for reducing math anxiety are. While researching, there was a lack of studies done in secondary school so the search broadened to include studies of undergraduate students who show similar symptoms of math anxiety. Then the methods found will be ordered from most to least effective. The methodology to be used in this paper will be an equation: score = positive – negative. To explain, the author counted the number of times a method is cited in a positive light and will take away the number of times that same method is cited negatively. The difference will be the score for that particular method. The highest score will be considered the most effective method to reduce math anxiety.

General Anxiety

Anxiety is defined as "an emotion characterized by heightened autonomic system activity, specifically activation of the sympathetic nervous system (i.e., increased heart rate,

blood pressure, respiration, and muscle tone), subjective feelings of tension, and cognitions that involve apprehension and worry" (Kazdin, 2000, p. 209). Another source defines anxiety as "an emotion characterized by apprehension and somatic symptoms of tension in which an individual anticipates impending danger, catastrophe, or misfortune. The body often mobilizes itself to meet the perceived threat: [m]uscles become tense, breathing is faster, and the heart beats more rapidly... Anxiety is considered a future-oriented, long-acting response broadly focused on a diffuse threat..." (VandenBos, 2015, p. 66). In academics today there appear to be two main types of anxiety: test anxiety and math anxiety (Hembree, 1990).

Definition of Math Anxiety

"Mathematics anxiety is characterized by feelings of apprehension and tension concerning manipulation of numbers and completion of mathematical problems in various contexts" (Hopko et al., 2003b, p. 648). Some typical signs of a math anxious individual are "avoidance of environments and careers that require the utilization of math skills and a tendency to sacrifice accuracy for speed when performing numeric tasks" (Hopko et al., 2003b, p. 648). Some people even described math anxiety as a feeling of "sudden death" (Tobias, 1978, p. 44). Math anxious students tend to run away from mathematics and any situation involving it which is apparent in their class selections in high school. "Mathematics anxiety involves increased physiological reactivity, negative cognitions, avoidance behavior, and substandard performance when presented with math stimuli" (Hopko, Mahadevan, Bare, & Hunt, 2003a, p. 178). Ashcraft and Moore (2009) have a similar definition for math anxiety, but they define it as an interference with a person's ability to solve mathematical problems in not only academic situations, but also ordinary life (p. 197). In the 2007 edition of the American Psychological Association's Dictionary of Psychology there was no definition for math anxiety. In 2015 they came out with a

new edition including this definition for math anxiety: "apprehensiveness and tension associated with the performance of arithmetic and other mathematical tasks. Often thought to be related to test anxiety, mathematics anxiety has been proposed as an important factor undermining the development of mathematical skills: It frequently causes distress, disrupts the use of working memory for maintaining task focus, negatively affects achievement scores, and potentially results in dislike and avoidance of all math-related tasks. It is seen in students of all ages, regardless of the actual math abilities, and is considered more prevalent in females than males. A number of factors are related to the phenomenon, including low self-esteem and self-efficacy, lack of confidence, trait anxiety, perfectionism, and previous negative experiences with the subject material. Teacher-based instruction that encourages students as they work through a math problem, teaches them effective skills in solving such problems, and demonstrates positive attitudes toward mathematics can reduce this type of anxiety. Cooperative learning, computer-assisted instruction, and the use of mathematical games to make the learning process more relaxed are also effective" (VandenBos, 2015, p. 628). For this paper, math anxiety will be defined as anxiety with mathematics as the stimuli or the trigger in any situation.

Chapter 2

The following paragraphs are the literature review for this paper. Both topics are organized in order of largest sample size to smallest sample size. Meta-analysis articles were given credit for the sample sizes of all the articles they collected. Any ties were organized by the authors' perceived relevance. In this chapter the reader will find first a review of literature for the causes of math anxiety. Second, the reader will find a review of literature for methods on reducing math anxiety.

Causes of Math Anxiety

Hembree (1990) analyzed 151 studies measuring math anxiety on students ranging from third grade to postsecondary (p. 35-36). Then he calculated correlations between math anxiety and "mathematics performance, student attitudes toward mathematics, avoidance behaviors, and measures of other anxieties" (Hembree, 1990, p. 37). He found that higher levels of math anxiety related slightly ($p < 0.01$ and correlation with mean^2 $r = -0.17$) with lower IQ scores (Hembree, 1990, p. 37-38). But consistently across all grades, higher levels of math anxiety related to lower mathematics performance (Hembree, 1990, p. 38). Next Hembree (1990) found "positive attitudes toward mathematics consistently related to lower mathematics anxiety" (p. 38). Finally he reported that students with math anxiety were less likely to take more high school mathematics classes and had little intentions to take more mathematics in college (Hembree, 1990, p. 38).

Research by Ashcraft and Moore (2009) looks into how math anxiety effects mathematics achievement (p. 197). They state, "[o]verall, math anxiety causes an 'affective drop,' a decline in performance when math is performed under timed, high-stakes conditions, both in laboratory tests as well as in educational settings. This means math achievement and proficiency scores for math-anxious individuals are underestimates of true ability" (Ashcraft & Moore, 2009, p. 197). They bring up the fact that our society now relies heavily on the statistics from standardized testing which makes it even more imperative to understand how students' math anxiety affects their test achievement (Ashcraft & Moore, 2009, p. 200). Ashcraft and Moore (2009) looked at the negative correlations between math anxiety and math achievement scores, high school math grades, college math grades, extent of high school math courses taken, and intent to enroll in more math courses (pg. 200). They summarize their information as the "higher one's level of

math anxiety, the lower one's score is on math achievement tests, the fewer math courses one takes, and the lower one's grades are in the math courses that are taken" (Ashcraft & Moore, 2009, p. 200). Also, the poorer the students' attitudes towards mathematics, the less likely they are to be taking further mathematics courses (Ashcraft & Moore, 2009, p. 200). Ashcraft and Moore (2009) suggest as a final point that it is not possible to truly judge students' mathematical ability in the form of a standardized test because high-stakes settings causes math anxiety causing a significant decline in performance (p. 204).

To gain some background information about math anxiety an article was found that described tools used in assessing math anxiety from the 1970's and on (Hopko et al., 2003a, p. 178). According to Hopko et al. (2003a), in the 1970's the Math Anxiety Rating Scale (MARS) was created with 98 items for the people to rank (p. 178). Since then multiple abbreviated versions of MARS have been created including The Abbreviated Math Anxiety Scale (AMAS), created by these authors, containing nine items the students rate from 1 (low anxiety) to 5 (high anxiety) (Hopko et al., 2003a, p. 179).

The nine items are:

1. having to use the tables in the back of a mathematics book,
2. thinking about an upcoming math test one day before,
3. watching a teacher work an algebraic equation on the blackboard,
4. taking an examination in a mathematics course,
5. being given a homework assignment of many difficult problems that is due the next class meeting,
6. listening to a lecture in mathematics class,
7. listening to another student explain a mathematical formula,

8. being given a "pop" quiz in mathematics class, and

9. starting a new chapter in a mathematics book (Hopko et al., 2003a, p. 180).

The participants of this study were 1,239 undergraduate students (729 females, 510 males) with a mean age of 19.6 years (Hopko et al., 2003a, p.179). Hopko et al. (2003a) found using statistical factor loadings (the higher the decimal the more strongly that item is associated with math anxiety) that the top cause of math anxiety was taking a test. Followed by thinking about a mathematics test the day before and getting a pop quiz, second and third top causes of math anxiety respectively (Hopko et al., 2003a, p. 180). Hopko et al. (2003a) also found a difference of math anxiety levels between genders, females reported more math anxiety than did males (pg. 180).

Jackson and Leffingwell (1999) looked at a different angle as to what causes math anxiety. They looked at how a teacher's attitude effects the students' math anxiety. Over three semesters Jackson and Leffingwell (1999) gave out surveys and got 157 respondents from a senior-level elementary-mathematics class which was required for all elementary education degrees (p. 583). In the survey they gave this prompt: "[d]escribe your worst or most challenging mathematics classroom experience from kindergarten through college" (Jackson & Leffingwell, 1999, p. 583). They also asked for the respondents "to describe factors that would have made their experiences more positive" (Jackson & Leffingwell, 1999, p. 583). Jackson and Leffingwell (1999) found three common groups where the anxiety-producing problem happened: elementary (especially third and fourth grade), high school (especially ninth through eleventh grade), and college level (especially first year) (p. 583). 27% of the sample had their traumatic encounter with math anxiety in their first year in college (Jackson & Leffingwell, 1999, p. 584). While 26% were in grades nine through eleven and 16% were in grades three and four (Jackson

& Leffingwell, 1999, p. 583-584). After sorting through the responses Jackson and Leffingwell (1999) categorized the common instructor behaviors as either overt, observable, or as covert, implied (p. 585). Overt behaviors coming from the instructor included verbal statements and behaviors that were hostile, unsupportive, and exhibiting gender bias (Jackson & Leffingwell, 1999, p. 585). Other overt behaviors consist of not giving enough time to explain or tutor, not answering questions, and putting down students when they have not met the unrealistic expectations (Jackson & Leffingwell, 1999, p. 585). Covert behaviors such as sighing in a demeaning manner, avoiding eye contact, and pretending the students trying to ask questions are invisible are common themes to cause math anxiety in this study (Jackson & Leffingwell, 1999, p. 585).

Oberlin (1982) wrote an article with an eye catching title of "How to Teach Children to Hate Mathematics." Though Oberlin (1982) does not implicitly say math anxiety, it is implied that where there is hatred of mathematics there will be math anxiety. He writes how children do not start school automatically hating mathematics, but rather turn to obtaining math anxiety (Oberlin, 1982, p. 261).

Oberlin (1982) lists eleven procedures that typically cause students to hate math:

1. have everyone do the same work, no differentiation
2. follow the book
3. homework everyday
4. plenty (or too much) of homework
5. no application to real life
6. only one way to solve every problem
7. assign more mathematics as a punishment

8. complete all the review work at the beginning of the textbook
9. drill and kill assignments
10. insisting papers are handed in in a specific way
11. every incorrect problem must be redone until correct (Oberlin, 1982, p. 261).

A combination of those eleven items are typically what is described when a person is asked the question: what does a typical mathematics classroom involve? Yet, 35 years ago this article was published telling the world how not to teach mathematics and teachers are still teaching this way!

In an article by Furner and Duffy (2002) they state how important it is in today's world to be able to use mathematics confidently (p. 67). Furner and Duffy (2002) list in their introduction four items that they believe could cause math anxiety, "communication and language barriers; quality of instruction; evaluation methods; and difficulty of material" (p. 68). Also included in their introductory to math anxiety they cite the causes of math anxiety described above from the Jackson and Leffingwell (1999) and Oberlin (1982) articles.

Tobias (1978) published a book titled *Overcoming Math Anxiety* which shows that forty years ago math anxiety was a problem and is still a problem today. Tobias (1978) writes how the confinement of having one right answer would cause panic among the mathematically anxious students (p.64). "Many math anxious adults recall with horror the timed tests they were subjected to in elementary, junior and senior high school with the emphasis on getting a unique right answer" (Tobias, 1978, p. 64). This quote shows how not only are timed tests a cause of math anxiety, but also how math anxiety can be something that will stick to students far past their days in the mathematics classroom. In 1993 Tobias took her book and revised and expanded it. In this new version she found some common mathematical myths that also cause

math anxiety: "Myth 1, that mathematics ability is inherent; Myth 2, that mathematical insight comes instantly if it comes at all; Myth 3, that only the very few can do mathematics; and Myth 4, that mathematics is a male domain" (Tobias, 1993, p. 9).

Methods of Reducing Math Anxiety

Hembree (1990) did a meta-analysis of 151 studies (p. 35). The studies he found compared the students' math anxiety posttreatment versus the math anxiety of the untreated students (Hembree, 1990, p. 42). The treatment styles were grouped into four categories: (a) classroom interventions, either a curriculum change or psychological interventions for the whole class; (b) behavioral, reducing the feelings of dread and nervousness; (c) cognitive, reducing concerns or worry about the topic; and (d) cognitive-behavioral, reducing worry, and dread or nervousness (Hembree, 1990, p. 42). What Hembree (1990) found is that a combination of the cognitive treatment of restructuring and the behavioral treatments of systematic desensitization or relaxation training out of the classroom was the most effective (p. 43). Cognitive restructuring included restructuring faulty beliefs students had and also building self-confidence in mathematics (Hembree, 1990, p. 43).

Tobias (1991) wrote an article describing her work on creating a Math Anxiety Clinic for undergraduate students. She brought together a team of counselors and mathematics teachers to work on strategies to change math anxious students' behaviors to be more like non-math anxious students' behaviors (Tobias, 1991, p. 91). 600 students went through her Math Anxiety Clinic and all went on to take mathematics in college and pass the class (Tobias, 1991, p. 91). The Math Anxiety Clinic starts with a math autobiography where the students are asked to relive past failures and successes with mathematics especially when mathematics became increasingly difficult for them (Tobias, 1991, p. 91). Also, they are asked about the attitudes towards

mathematics that people in their lives had, for example, a parent had a fear of mathematics (Tobias, 1991, p. 91). Next comes "Group De-Tox" where the group discusses past experiences with mathematics and bonds together creating an environment where they can be honest and sharing is always encouraged (Tobias, 1991, p. 91). The students are instructed to do what they call "the divided-page exercise" where students write down on the left side of the page what they are feeling while working through a mathematics problem on the right (Tobias, 1991, p. 91). Then the group discusses the statements made on the left side of the paper (Tobias, 1991, p. 91). The last thing that the Math Anxiety Clinic gave the students was assertiveness training for when they returned to a mathematics classroom (Tobias, 1991, p. 91).

They used the "Math Anxiety Bill of Rights" developed by Sandra L. Davis:

I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.

I have the right to ask whatever questions I have.

I have the right to need extra help.

I have the right to ask a teacher or TA for help.

I have the right to say I don't understand.

I have the right not to understand.

I have the right to feel good about myself regardless of my abilities in math.

I have the right not to base my self-worth on my math skills.

I have the right to view myself as capable of learning math.

I have the right to evaluate my math instructors and how they teach.

I have the right to relax.

I have the right to be treated as a competent adult.

I have the right to dislike math.

I have the right to define success in my own terms (Tobias, 1991, p. 91).

In Tobias' (1978) book she wrote about her experience of visiting a group's session in her Math Anxiety Clinic.

Jackson and Leffingwell (1999) from their survey concluded that teachers should be mindful of their impact on their students (p. 585). "Students tend to internalize their instructors' interest in, and enthusiasm for, teaching mathematics" (Jackson & Leffingwell, 1999, p. 585). Teachers can help reduce math anxiety in their students by discussing their own possible math anxiety and how they overcame it; projecting to students they are interested in and excited by mathematics; offering additional help and time to students; having mutual respect as a rule in the classroom; offering one-on-one tutoring sessions for students who need more help; supplemental review before an exam; seeking help from coworkers when overwhelmed instead of taking it out on the students; and offering other times for students to take the exam (Jackson & Leffingwell, 1999, p. 586).

Stuart (2000) did a research study by developing a math survey that she gave out to twenty-two female and twenty-five male students age's nine to twelve (p. 331). She found people like to do what they are good at and people have to believe they are good at mathematics in order to feel good about mathematics (Stuart, 2000, p. 334). Stuart (2000) is a teacher and she expresses, "[i]f I could somehow relate mathematics to what the students enjoyed and felt successful with, then I could help them overcome or completely avoid math anxiety" (p. 331).

The NCTM has developed some suggestions to help reduce stress and anxiety in the mathematics classroom:

1. Accommodate different learning styles.

2. Create a variety of testing environments.
3. Design experiences so that students feel positive about themselves.
4. Remove the importance of ego. It should not be a measure of self-worth.
5. Emphasize that everyone makes mistakes.
6. Make math relevant.
7. Empower students by letting them have input into their own evaluations.
8. Allow for different social approaches.
9. Emphasize the importance of original quality thinking rather than manipulation of formulas.
10. Characterize math as being a human endeavor (Stuart, 2000, p. 334).

Stuart (2000) tells the readers her success stories by implementing these NCTM methods of reducing math anxiety in her classrooms (p. 334-335). She says she started incorporating cooperative groups and giving a variety of different problems (Stuart, 2000, p. 334). Her students started understanding that it is possible to have more than one way to solve a problem or more than one answer (Stuart, 2000, p. 334). Stuart (2000) started integrating other subjects like science and geography into her mathematics class (p. 335). She had them write papers of how they solved a realistic problem and compare-and-contrast papers on mathematics concepts (Stuart, 2000, p. 334). Stuart (2000) also had them write journals to clarify concepts, questions, and to verbalize their feelings (p. 334). Lastly, she held conferences with each student to discuss their strengths; and where and how they were going to improve their areas needing improvements (Stuart, 2000, p. 335). By doing these different teaching strategies "my students who had seemed to have the most math anxiety made the most dramatic improvements, with learning indexes increasing 10 to 30 percentage points" (Stuart, 2000, p. 335).

Shodahl and Diers (1984) looked at the problem of math anxiety in college students and wanted to find a way to "break up this self-defeating cycle" (p. 34). Her solution was a course called Math Without Fear that met once a week for two hours for one semester (Shodahl & Diers, 1984, p. 34). The goal of the class "was not to eliminate math anxiety but rather to lead students to a recognition of the emotional blocks regarding their ability to do math" (Shodahl & Diers, 1984, p. 36). At the point in time that this article was published 40, students had taken the class so far (Shodahl & Diers, 1984, p. 36). In this course the first thing the instructors do is build rapport with the students by being supportive and understanding (Shodahl & Diers, 1984, p. 34). The students then share their history with mathematics to their peers and fill out a mathematics autobiography (Shodahl & Diers, 1984, p. 34). Shodahl and Diers (1984) continue saying that the students keep a weekly journal where they respond to the chapters in a math anxiety book that they're required to read (Shodahl & Diers, 1984, p. 34). The students also write about any experiences with mathematics they had that week, then discuss it with the class (Shodahl & Diers, 1984, p. 34). Next the students learn relaxations techniques like "diaphragmatic breathing, progressive muscle relaxation, and guided imagery" while listening to music designed for relaxation (Shodahl & Diers, 1984, p. 34). In addition, the instructors bring in guest speakers to support the points they are trying to make in the class (Shodahl & Diers, 1984, p. 35). In the class they try to eliminate some of the confusion that comes with mathematics by answering the question of why things work (Shodahl & Diers, 1984, p. 35). The instructors do this by playing games and showing mathematics concepts "in a hands-on visual way in order to encourage more right brain perception of the concepts and hence a fuller understanding of the concepts" (Shodahl & Diers, 1984, p. 35). Grades in the class are not evaluating what is typical of mathematics classes like having the right solution or getting done

the fastest, but are used to grade "active attendance" in the class (Shodahl & Diers, 1984, p. 35). The students took the Mathematics Anxiety Rating Scale which goes from 0 = no anxiety to 490 = extreme anxiety at the beginning and end of the semester (Shodahl & Diers, 1984, p. 36). The mean score went from 311.3 at the start of the class to 213 at the end which suggests that the class using multiple methods was an effective way to reduce math anxiety (Shodahl & Diers, 1984, p. 36).

Furner and Duffy (2002) describe reducing math anxiety in a manner where the teacher becomes a counselor trying to help the students overcome their math anxiety. The authors then go into their own ideas of how to reduce math anxiety. Furner and Duffy (2002) created a 'Mathitude' Survey for students to take at the beginning of the school year so "teachers can assess their students' dispositions toward math" (p. 70). They also believe, "teachers can change attitudes by using effective instructional techniques, focusing on what students can do, encouraging multiple outcomes, and being sensitive to past histories of frustration and failure" (Furner & Duffy, 2002, p. 71). Furner and Duffy (2002) state that journal writing is one way for students to reduce math anxiety by allowing them to express how they feel about mathematics and what they understand of mathematical concepts (p. 70). For students that have trouble writing, the teacher may adapt the journal writing to group discussions or audio journals (Furner & Duffy, 2002, p. 70). The third method of reducing math anxiety that Furner and Duffy (2002) discuss is using the internet for additional practice of mathematical concepts (p. 71). By using the internet the teacher is taking away the pressure and anxiety that most students associate with traditional practicing techniques (p. 71). The last method is bibliotherapy where the characters in a children's book have similar experiences as the students with math anxiety (Furner & Duffy,

2002, p. 71). The book then prompts discussions on math anxiety and how the students feel about it (Furner & Duffy, 2002, p. 71).

Swanson (2013) gives more of a middle school perspective strategy of taking a step back and breathing. "This article examines both teachers' and students' emotional reactions to challenging mathematics problems and, more important, the strategies they use to cope with anxiety and to re-engage and grapple with these problems" (Swanson, 2013, p. 94). First Swanson (2013) did the experiment on her pre-service teachers by presenting them with a middle school mathematics problem and asking them what their initial emotional reactions are (p. 96). She then continued asking the pre-service teachers who expressed anxiety how they were going to cope with the anxiety (Swanson, 2013, p. 96). The methods to reduce their math anxiety were all forms of self-talk strategies where they reminded themselves to slow down and breathe (Swanson, 2013, p. 96). Swanson (2013) repeated the experiment with middle school students and went through with them as to how to cope with their math anxiety and how to continue on to solve the problem (Swanson, 2013, p. 97). The author then gives a three step lesson to help students reduce their math anxiety and then problem solve: "recognizing and acknowledging emotional reactions, developing self-talk and coping strategies, and providing cognitive scaffolding during the problem-solving process" (Swanson, 2013, p. 98).

Hébert and Furner (1997) focus on the strategy bibliotherapy which "is the use of reading to produce affective change and to promote personality growth and development" to reduce math anxiety (p. 169). Bibliotherapy helps math anxious students by providing them with a good read where the students relate to the character in the book who also has math anxiety (Hébert & Furner, 1997, p. 172). The students then feel relieved that they are not alone with these feelings of math anxiety and they learn how to cope by reading about how the character copes (Hébert &

Furner, 1997, p. 172). But as Hébert and Furner (1997) continue bibliotherapy does not stop at just reading a book, the students then need to "become involved in discussions, counseling, and follow-up techniques, such as role-playing, creative problem solving, relaxation with music, art activities and journal writing" (p. 172).

Chapter 3

Causes of Math Anxiety

The identified causes will be ranked based on frequency of positive citations in the literature search. If two methods are tied then they will be reported as tied. In this manner the author will establish a ranked list of causes of math anxiety in the secondary mathematics classroom. When analyzing the literature review, the author identified five categories of reasons causing math anxiety: (a) tied for first are the factors of timed tests and instructional methods; (b) second is teachers' attitudes; and (c) tied for third is students' attitudes and materials.

Timed tests. The first two factors that cause math anxiety that were cited the most were tied with four citations each. The first of the two is timed tests. The top three factors that Hopko et al. (2003a) found in their study at what factors causes math anxiety all had the common denominator of testing. Specifically the top factor causing math anxiety was "taking an examination in a math course" (Hopko et al., 2003a, p. 180). Second was the factor "thinking about an upcoming math test 1 day before" (Hopko et al., 2003a, p. 180). The third factor was "being given a 'pop' quiz in math class" (Hopko et al., 2003a, p. 180). Evaluation methods like taking a test or a timed test was shown to be one of the top causes of math anxiety (Ashcraft & Moore, 2009; Hopko et al., 2003a; Jackson & Leffingwell, 1999; Tobias, 1978).

Tobias (1978) interviewed math anxious individuals who had been out of school for multiple years and they still remember the stress and tension caused by timed tests (p. 31).

Of the people surveyed by Jackson and Leffingwell (1999) those students who experienced math anxiety in elementary school remember the cause of difficulty came with taking timed tests and competing against their peers (p. 583). Of the students who experienced math anxiety in the post-secondary level they share that they viewed exams as "punishment and as a vindictive form of retaliation" (Jackson & Leffingwell, 1999, p. 585). They also wrote in the survey that one of their causes of math anxiety was when the exam did not follow what they learned in the lessons (Jackson & Leffingwell, 1999, p. 585).

Ashcraft and Moore (2009) looked at how high stakes testing causes math anxiety, which then causes the students to not perform as highly as they could. Hence, not only does timed testing, even testing in general, cause math anxiety it also causes students to not perform to their full potential. Testing students is not getting accurate measurements of their mathematical ability. From these sources the author could see that one of the leading causes of math anxiety is the stressful situations of testing mathematics.

Instructional methods. The second reason causing math anxiety in the tie for the top reason is instructional methods. It was intriguing to this author how one of the most cited reason causing math anxiety could come from the teacher. Oberlin (1982) writes children do not hate mathematics at first, they learn to hate it once they start school (p. 261).

The qualities of instruction that causes math anxiety includes when the teacher gives poor or rushed explanations (Jackson & Leffingwell, 1999, p. 585). Also, when the teacher inaccurately assesses the students' prior knowledge and continues with the lesson anyway (Jackson & Leffingwell, 1999, p. 585).

Assigning homework every day is typical in a traditional mathematics classroom, but that teaching method is one of the reasons causing math anxiety (Hopko et al., 2003a; Oberlin, 1982).

If the teacher assigns too much homework or the typical "drill and kill" homework assignments or even assigning more homework as a punishment causes math anxiety (Oberlin, 1982).

The purpose of drill and kill homework is to get the students to memorize mathematical skills instead of internalizing them and understanding the mathematical concepts behind the procedures. When students face difficulty in memorizing the facts, for example the multiplication tables or formulas, that begins the math anxiety and it continues from there (Jackson & Leffingwell, 1999, p. 583).

When people think about mathematics, they think of it as a black and white subject with no gray areas in between. But that thinking and that instruction method of only one right answer and one way to get it is another way to cause math anxiety (Tobias, 1978; Oberlin, 1982). Not to mention that upper division mathematics courses reward students who are able to think creatively and flexibly with mathematics. The students feel pressured to get the right answer and when that does not happen they panic and become anxious (Tobias, 1978).

Other factors that Hopko et al. (2003a) studied in causing math anxiety were when teachers stood in front of the class working on the blackboard a complicated concept and the typical instructor method of lecturing. Also, under teaching methods, teachers not differentiating the work for their students and teachers not showing their students mathematics in real life situations (Oberlin, 1982, p. 261).

The traditional way of teaching mathematics is an instructional method involving much of what is said in this section. The traditional mathematics classroom involves a review of the previous night's homework, lecture, the teacher is at the board doing mathematics problems, and the students are assigned homework every night (NCTM, 1991, p. 1). Traditional mathematics

teaching methods are the second of the tie for the leading cause of math anxiety cited in the review of literature.

Teachers' attitudes. Teachers' attitudes, like believing in common mathematical myths and projecting that belief on their students, are the second most frequently cited causes of math anxiety (Tobias, 1993). These myths include: only people who have the mathematical mind can do mathematics; good mathematics is fast mathematics; only select few can do mathematics; and mathematics is male dominated (Tobias, 1993).

Teachers who portray angry attitudes towards students who ask questions or ask for clarification had negative impact on their students and their math anxiety (Jackson & Leffingwell, 1999, p. 584). Also, teachers who are angry for reasons outside of the classroom and they take it out on their students (Jackson & Leffingwell, 1999, p. 584).

Insensitive and uncaring attitudes teachers may have are a cause of math anxiety, like ignoring students who ask for help or making students go to the board when they do not know how to do a problem and will be embarrassed in front of their peers (Jackson & Leffingwell, 1999, p. 584).

Finally, teachers showing gender bias towards their students is a teacher attitude that causes math anxiety for whichever gender is receiving the neglect (Jackson & Leffingwell, 1999, p. 584). Teachers who have gender biases towards women and/or believe in the myth that mathematics is a male dominated subject push women away from potential futures because of the math anxiety the teachers now caused.

Hembree (1990) found in his meta-analysis a correlation between teachers' and parents' negative attitudes towards mathematics and the students' high levels of math anxiety (p. 38).

Teacher attitudes that are uncaring, angry, and biased are the third leading cause of math anxiety cited in the review of literature.

Students' attitudes. The last two most cited reasons causing math anxiety tied for third with one citation each. Because the author just wrote how teachers' attitudes cause math anxiety, the author will continue with how the students' attitudes cause math anxiety. In Hembree's (1990) meta-analysis study he looked at how students' attitudes correlated with math anxiety (p. 38). He found that positive attitudes toward mathematics related to lower math anxiety which was consistent across all grade levels (Hembree, 1990, p. 38). Which implies that a students' negative attitude towards mathematics relates to and causes higher math anxiety. To specify, the lower a students' enjoyment of mathematics, self-confidence in mathematics, self-concept in mathematics, and motivation in mathematics the higher the students' math anxiety (Hembree, 1990, p. 39). Students' negative attitude towards mathematics is the first of the tied leading causes of math anxiety cited in the review of literature.

Materials. The last cause of math anxiety, also the second item tied for fourth, is the material taught in mathematics classrooms. Jackson and Leffingwell (1999) did a survey and found that 16 percent of their participants experienced the start of math anxiety in third and fourth grade (p. 583). One of the reasons for the start of the math anxiety was how difficult the material was (Jackson & Leffingwell, 1999, p. 583). Students specifically remembered the topics that caused the math anxiety: fractions; and memorizing multiplication tables and formulas (Jackson & Leffingwell, 1999, p. 583). Difficult materials or concepts is the second cause of math anxiety tied for the fourth overall leading cause of math anxiety.

The following table, see Table 1, is a brief summary of the research done in this paper. On the left hand side of the table are the factors causing math anxiety while on the corresponding

right hand column are the articles supporting that factor in alphabetical order. The table was used to organize the factors of math anxiety and keep track of which articles cited which factor. Then the table was ordered by the factor with the most citations to the factor with the least citations.

Table 1

Factors Causing Math Anxiety and Their Citations

Factors	Citations
Timed Tests	Ashcraft and Moore (2009) Hopko, Mahadevan, Bare, and Hunt (2003a) Jackson and Leffingwell (1999) Tobias (1978)
Instructional Methods	Hopko et al. (2003a) Jackson and Leffingwell (1999) Oberlin (1982) Tobias (1978)
Teachers' Attitudes	Hembree (1990) Jackson and Leffingwell (1999) Tobias (1978)
Students' Attitudes	Hembree (1990)
Materials	Jackson and Leffingwell (1999)

Table 1

Methods of Reducing Math Anxiety

The identified methods will be ranked based on frequency of positive citations in the literature search. If two methods are tied then they will be reported as tied. In this manner the author will establish a ranked list of best practices for reducing math anxiety in the secondary mathematics classroom. When analyzing the literature review the author categorized the methods reducing math anxiety into six categories: (a) first, expressing feelings; (b) second, anxiety management techniques; (c) three categories tied for third, students' attitudes, instructional methods, and bibliotherapy; and (d) fourth, teachers' attitudes.

Expressing feelings. The first category of methods reducing math anxiety is expressing how mathematics makes students feel with six citations. This general category can be split into

two ways of expressing feelings: verbal like discussions and written like journals. Both Shodahl and Diers (1984) and Tobias (1991) created a course with the goal of reducing students' math anxiety. Shodahl and Diers (1984) called her course Math Without Fear while Tobias (1991) called her course Math Anxiety Clinic. Both courses start in a support group atmosphere where the students discuss their past experiences with mathematics, their mathematics autobiography (Shodahl & Diers, 1984, p. 34; Tobias, 1991, p. 91). Shodahl and Diers (1984) emphasizes that the students are encouraged to share with the group, but are never forced (p. 34). The group work continues throughout the course. "Critical to the treatment of math anxiety is group work" (Tobias, 1991, p. 91). Students who are math anxious feel like they are the only ones who feel this way when presented with mathematics, the group dynamic shows them they are not alone (Tobias, 1991, p. 91). Throughout the rest of the courses, Shodahl and Diers (1984) and Tobias (1991) both stress the importance of the groups' atmosphere being supportive and understanding; a safe place where the students can be honest about their feelings of mathematics.

Furner and Duffy (2002) also write about how group discussions can be used to reduce math anxiety. "To overcome or reduce their math anxiety, students must first be allowed to express their true feelings about math and how they arrived at their given disposition" (Furner & Duffy, 2002, p. 70). Furner and Duffy (2002) believe that one way of doing that is in a group discussion similar to what is described previously. NCTM (2000) also agrees saying that students with math anxiety need to face it in some form of group discussion or supportive environment.

Swanson (2013) describes a lesson she did with her middle schoolers. She provided them with a mathematical problem and first asked them how they felt about the problem, starting a group discussion with her students (Swanson, 2013, p. 96). In her reflection she says, "I do not

believe that I had ever before asked either adults or students how a mathematics problem made them feel" (Swanson, 2013, p. 99). Swanson (2013) explains that the first step to help students solve a problem is to first help "students recognize and cope with their anxiety" which will then clear "the way so that students could cognitively engage with the problem" (p. 98). To get students to recognize and discuss their anxiety she included questions to ask the students like "what did you say to yourself when you first read this problem?" (Swanson, 2013, p. 98).

Both courses are also encouraged to share their feelings about mathematics in a journal (Shodahl & Diers, 1984; Tobias, 1991). Tobias (1991) calls it "The Divided-Page Exercise" where her students are asked to write out "their negative self-statements on the left-hand side of their note paper as they do their mathematics" (p. 91). Typical topics for the left side of their paper include answering questions as to what is difficult about the problem and what could make it easier (Tobias, 1991, p. 91). In Shodahl and Diers's (1984) course students are "required to keep a weekly journal… to jot down any experience with numbers they might have had during the week" (p. 34). The point of this assignment is so the students see how much mathematics they use in their everyday lives and if they come across a difficult mathematics problem they can write it down and discuss it in class (Shodahl & Diers, 1984, p. 34).

Furner and Duffy (2002) also include the option of "journal writing for students to express understanding of mathematical concepts or to share feelings about and experience with math" (p. 70). They included in the article a sidebar of questions for students to answer in their journal (Furner & Duffy, 2002, p. 71). One example is question number two: "Imagine yourself doing or using math either in or out of school. What does it feel like? Describe" (Furner & Duffy, 2002, p. 71).

Furner and Duffy (2002) make a point comparing group discussion versus journal writing. "Students with written language difficulties may find cooperative learning group discussions more useful than written journal entries" (Furner & Duffy, 2002, p. 70). They also include other ideas like an audio journal if students are better at expressing verbally over written (Furner & Duffy, 2002, p. 70).

From the review of literature, the top method to reduce math anxiety is when the students express their feelings, past and present, about mathematics in either a discussion setting or in a journal.

Anxiety management techniques. Anxiety reducing techniques, including relaxation and self-talk, is the second most cited method reducing math anxiety with five citations. NCTM (2000) gives some general suggestions to reduce math anxiety including anxiety management and desensitization. Systematic desensitization is "a form of behavior therapy in which counterconditioning is used to reduce anxiety associated with a particular stimulus" (VandenBos, 2015, p. 1061). In this case the stimulus would be mathematics. It has three stages: deep-muscle relaxation; various situations that would cause math anxiety are listed from weakest to strongest; and then presented in imagination or reality starting with the weakest while in deep-muscle relaxation (VandenBos, 2015, p. 1061). "Since the muscle relaxation is incompatible with the anxiety, the client gradually responds less to the anxiety-provoking situations" (VandenBos, 2015, p. 1061).

Hembree (1990) did a meta-analysis and found "the most common behavioral treatment mode was systematic desensitization" which when combined with "anxiety management training and conditioned inhibition, were highly successful in reducing mathematics anxiety levels" (p.

43). Those techniques listed above all have a component of relaxation training (Hembree, 1990, p. 43).

Shodahl and Diers's (1984) class called Math Without Fear also used relaxation techniques to reduce math anxiety. "Music specially designed for relaxation is played while the students practice diaphragmatic breathing, progressive muscle relaxation, and guided imagery" (Shodahl & Diers, 1984, p. 34). The students practice these techniques throughout the rest of the course and ideally the rest of their lives (Shodahl & Diers, 1984, p. 34). The instructors also invited an acupressure expert to speak to the students how they can use acupressure to relax (Shodahl & Diers, 1984, p. 35).

Swanson (2013) gave a mathematics problem to some teacher candidates and asked them what their initial thoughts and feelings were when given the problem (p. 96). Then they were asked to write about their feelings and thoughts while going through the problem solving process (Swanson, 2013, p. 96). She found the preservice teachers that initially showed math anxiety when given the problem used coping methods of relaxing and self-talk. Swanson (2013) continued by posing the same process to middle schoolers and her lesson plan on teaching students how to cope with math anxiety she did with those middle schoolers (p. 96). After the students had applied the coping strategies including relaxing and self-talking "students reflected that the math was actually easy" (Swanson, 2013, p. 97). Swanson (2013) provides a summary of self-talk strategies: "take a deep breath and relax; take your time to re-engage; reread the problem and find what you know; and take it one step at a time" (p. 98). She reflects that this discovery of reducing math anxiety has changed her teaching practice (Swanson, 2013, p. 99).

Tobias (1978) also discusses how self-talk strategies can be used to reduce math anxiety. These five citations support the method of reducing math anxiety by using anxiety management techniques such as breathing, relaxing, and using self-talk.

Students' attitudes. There were three methods of reducing math anxiety tied with three citations each. The first of these methods of reducing math anxiety is students' attitudes. Stuart (2000) is a fifth grade teacher and she conducted a survey for her students because she wanted to see where they "fit into the continuum of mathematics confidence" (p. 331). Stuart (2000) noticed her students consistently wrote in the survey that their favorite subject was the one they enjoyed the most and had been recognized for their success in it (p. 331). From her survey she collected data relating her students' likeness of mathematics to their confidence in mathematics and their worry level over mathematical tasks (Stuart, 2000, p. 332). Those students that like mathematics also have high levels of confidence in mathematics and little worry when it comes to mathematical tasks (Stuart, 2000, p. 333). Whereas the students that said they disliked mathematics had a low confidence level in mathematics and worried when asked to do mathematical tasks (Stuart, 2000, p. 332).

In order to reduce her classes' math anxiety she implemented multiple different teaching strategies including ones to improve her classes attitudes towards mathematics. Her students began to take risks in problem-solving which increased their mathematics confidence (Stuart, 2000, p. 334). By using other subjects where her students were already confident she helped them feel more successful in mathematics (Stuart, 2000, p. 334). Their confidence also increased when they were given meaningful contexts for their mathematical skills (Stuart, 2000, p. 335).

Hembree (1990) also looked at how increasing students' attitudes lowered their math anxiety. In his meta-analysis study he found that restructuring faulty beliefs, like mathematical

myths (mathematical mind, mathematics is male dominated, mathematics is inherent), and building "self-confidence in mathematics produced a moderate reduction in mathematics anxiety" (Hembree, 1999, p. 43). When that method is combined with systematic desensitization or relaxation training it becomes highly successful in reducing math anxiety levels (Hembree, 1999, p. 43).

Tobias (1991) discusses the steps in her Math Anxiety Clinic; the last step that the students go through is called assertiveness training (p. 91). "This technique, designed by feminist therapists, is meant to give students the training they will need to survive in the next class" (Tobias, 1991, p. 91). They follow the "Math Anxiety Bill of Rights" which was developed by Sandra Davis and is on page fifteen of this paper (Tobias, 1991, p. 91). To summarize, the Math Anxiety Bill of Rights is fourteen statements to keep students attitudes and confidence up when confronted with future mathematics endeavors (Tobias, 1991, p. 91). They are sentences reminding the students they are capable of reducing the math anxiety and of learning mathematics (Tobias, 1991, p. 91). For example, one statement says, "I have the right learn at my own pace and not feel put down or stupid if I'm slower than someone else" (Tobias, 1991, p. 91). This assertiveness training is important because the students that went through the Math Anxiety Clinic have to eventually learn how to manage it on their own without the constant guidance of their mathematics mental health instructor (Tobias, 1991, p. 91). These three citations have students' attitudes in common and how their attitudes can affect math anxiety. The first of the tied for third most cited methods of reducing math anxiety is to make students' negative attitudes towards mathematics into positive attitudes.

Instructional methods. The second of the tied methods to reduce math anxiety for third most cited is instructional methods. Jackson and Leffingwell (1999) suggest that mathematics

teachers should include in their instruction "additional reinforcement and time to students who suffer from anxiety and need help" (p. 586). Also, to help reduce the math anxiety in their students, include opportunities for one-on-one tutoring sessions for those students who have more time consuming questions (Jackson & Leffingwell, 1999, p. 586). "Giving written and verbal supplemental reviews of key terminology and processes as examination time approaches" is another suggestion to include into instruction to reduce math anxiety (Jackson & Leffingwell, 1999, p. 586). Lastly, Jackson and Leffingwell (1999) propose that teachers offer additional times for testing so students have some one-on-one tutoring time to reduce their math anxiety and better prepare them to succeed on the test (p. 586).

Stuart (2000) applied different instructional methods to her class with a high number of students with math anxiety. She started "incorporating cooperative groups in problem-solving situations" instead of standing at the front of the class and lecturing (Stuart, 2000, p. 334). Stuart (2000) also started including more writing into her classroom, formally and informally (p. 334). "I gave students prompts generated from fictitious businesses that needed our class to solve problems related to the current topic of study. Students wrote letters to the business or company, explaining our solutions" (Stuart, 2000, p. 334). Stuart (2000) started combining other subjects with mathematics like science and social studies. She gave the numbers and the mathematical procedures meaning by giving them a context (Stuart, 2000, p. 335). For example, she had a lesson teaching the mathematics behind drawing a map that is to scale (Stuart, 2000, p. 335). Her students used mathematical skills in science experiments, calculating results and conclusions (Stuart, 2000, p. 335). Stuart (2000) made mathematics relevant to the students. The last instructional method she included is "empower[ing] students by letting them have input into their own evaluations" (Stuart, 2000, p. 334). Stuart (2000) held individual conferences with the

students where they discussed the students' strengths and where they could improve (p. 335). She helped them develop a plan of action specific to them (Stuart, 2000, p. 335). Giving the students some control in their mathematics education empowered the students (Stuart, 2000, p. 335). Also, Stuart (2000) and the student signed an agreement stating strategies to help the student improve which was a "great motivator" (p. 335).

Shodahl and Diers (1984) includes some instructional methods in her Math Without Fear that are effective in reducing math anxiety. In her course, the instructors bring in speakers to enforce the points being made in class (Shodahl & Diers, 1984, p. 35). For example, "a vocational counselor discusses the career options open to those who have a good math background" (Shodahl & Diers, 1984, p. 35). NCTM (2000) agrees saying, "[i]n this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures" (p. 5). The instructors of this course also discuss the nature and history of mathematics in an attempt to eliminate confusion for the students (Shodahl & Diers, 1984, p. 35). Mathematical myths that were discussed earlier as a reason causing math anxiety are shown to be just myths (Shodahl & Diers, 1984, p. 35). In this course, students play mathematics games to show how mathematics can be fun, concepts are "presented in a hands-on, visual way in order to encourage more right brain perception of the concepts and hence a fuller understanding of the concepts" (Shodahl & Diers, 1984, p. 35).

The instructional methods discussed in these three articles are not the traditional mathematics teaching methods as discussed earlier in this paper. Instructional methods that help to reduce math anxiety include: being more flexible and providing more time to prepare for exams; allowing additional time for students to ask questions to fully understand the concept; make mathematics relevant; incorporate other subjects like writing, science and social studies;

and use hands-on, visual representations. These instructional methods are the second of the tied methods for third most cited method to reduce math anxiety.

Bibliotherapy. The last strategy of reducing math anxiety that is tied for the third most cited method is using bibliotherapy. Bibliotherapy uses structured reading materials to reinforce concepts, strategies, enhancing changes, and foster growth and development (VandenBos, 2015, p. 124). The use in mathematics classrooms is when the students with math anxiety are given a book where the main character also has math anxiety (Hébert & Furner, 1997, p. 172). The students identify with the character and realize they are not alone facing math anxiety (Hébert & Furner, 1997, p. 172). "As readers enjoy the book, they learn vicariously through the characters in the book" (Hébert & Furner, 1997, p. 172). Students see new ways to look at math anxiety and their behaviors might change similarly to how the character's behaviors changed toward math anxiety (Hébert & Furner, 1997, p. 172). Successful bibliotherapy also involves follow up discussions with the students about the book either in a journal or in a group (Hébert & Furner, 1997, p. 172). After reading the book some follow up activities could include: "role-playing; creative problem solving; relaxation with music; art activities; and journal writing (Hébert & Furner, 1997, 172).

Hébert and Furner (1997) give a sample of a bibliotherapy lesson might look like using the book *Math Curse* (p. 170). He includes lists of possible themes/key concepts; possible introductory activities; selected passages from *Math Curse* to be used in discussion; discussion questions; and possible follow-up activities (Hébert & Furner, 1997, 170-172). To start the lesson of bibliotherapy this introductory activity could be used: "have the students define the terms 'curse' and 'anxiety'" (Hébert & Furner, 1997, 172). Then after they read the book, or part of the book, the students can discuss in class or write in a journal one of the discussion

questions like "If you could design a stress-free math class, what would it be like?" (Hébert & Furner, 1997, 171). After the students are done reading the book they could participate in a follow-up activity like "have students write letters to the main character in *Math Curse* describing how they felt about the events of the day described in the story" (Hébert & Furner, 1997, 171).

NCTM (2000) also mentions the use of bibliotherapy in secondary classrooms to reduce math anxiety. Furner and Duffy (2002) look at how bibliotherapy "prompts discussion of feelings to help get to the bottom of issues" (p. 71). Books allow students to compare their feelings with the character's feelings in the book and discuss them (Furner & Duffy, 2002, p. 71). The last method of reducing math anxiety in the tie for the third most cited method is using bibliotherapy in the classroom to help the students to discuss their feelings about mathematics.

Teachers' attitudes. The final method of reducing math anxiety with two citations is the teachers' attitudes. Shodahl and Diers (1984) emphasizes in her Math Without Fear course in which "the instructors present themselves as supportive and understanding people who recognize the problem of math anxiety" (p. 34).

Jackson and Leffingwell (1999) state, "[s]tudents tend to internalize their instructors' interest in, and enthusiasm for, teaching mathematics" (p. 585). Techers' attitudes play a role in students' math anxiety. One way teachers' can have a better attitude to reduce math anxiety is sharing with the students possibly their own math anxiety, or anxiety in a different subject (Jackson & Leffingwell, 1999, p. 586). Teachers can share what methods they used to cope with the anxiety and it lets the students know they are not the only ones with anxiety issues (Jackson & Leffingwell, 1999, p. 586).

Also, instructors can make "a conscious choice to project to students their own interests in, and enjoyment of, mathematics" (Jackson & Leffingwell, 1999, p. 586). In the classroom, making respect a rule that all students and teachers need to follow to encourage productive struggle (Jackson & Leffingwell, 1999, p. 586). Lastly, Jackson and Leffingwell (1999) suggest that if a teacher is feeling overwhelmed, instead of taking it out on the students, they should reach out to colleagues, so they can keep the positive attitude in the classroom (p. 586). The last method in the literature review to reduce math anxiety is to keep the teachers' attitudes positive and helpful towards the students.

The following table, see Table 2, is a brief summary of the research done in this paper on the methods to reduce math anxiety. On the left hand side of the table are the different categories of methods to reduce math anxiety while on the corresponding right hand side are the citations that give evidence to the methods. The table was used to keep track of methods cited while reading the researched articles. Then after analyzing and synthesizing the author ordered the table from most effective (most citations) to least effective (least citations).

Table 2

Methods to Reduce Math Anxiety and Their Citations

Methods	Citations
Expressing Feelings	Furner and Duffy (2002) NCTM (2000) Shodahl and Diers (1984) Stuart (2000) Swanson (2013) Tobias (1991 & 1978)
Anxiety Management Techniques	Hembree (1990) NCTM (2000) Shodahl and Diers (1984) Swanson (2013) Tobias (1978)
Students' Attitudes	Hembree (1990) Stuart (2000) Tobias (1991)

Instructional Methods	Jackson and Leffingwell (1999) Shodahl and Diers (1984) Stuart (2000)
Bibliotherapy	Furner and Duffy (2002) Hébert and Furner (1997) NCTM (2000)
Teachers' Attitudes	Jackson and Leffingwell (1999) Shodahl and Diers (1984)

Chapter 4

Conclusion

By defining anxiety, math anxiety and looking at what math anxiety could look like one can begin to understand how math anxiety can affect people in their education and their lives. In this paper math anxiety was defined as anxiety, feelings of apprehension and tension, with mathematics as the stimulus or trigger. Reducing math anxiety is important especially in the secondary classroom because students by shutting the door on mathematics are also shutting the door on many desirable future opportunities. As a future secondary mathematics teacher the author has a passion for opening those doors for students with math anxiety and showing them how bright their future is with the mathematical understanding. With this research the author now knows the research based methods as to how to make that possible.

Chapter two was the author's literature review of the peer reviewed articles she found under the categories of causes of math anxiety and methods of reducing math anxiety. The peer reviewed journal articles gave the author insight to her two central questions. First, what are the research based methods for reducing math anxiety? Second, of the identified methods, which are most effective? To rank the methods in order of which one works the best, the author will use frequency of positive and negative citations as her measurement. The methodology used in this paper was an equation: score = positive – negative. In other words, she counted the number of times a method was cited in a positive light and took away the number of times that same method

is cited negatively. The difference was the score for that particular method as displayed in the tables. No negative citations were found in this review of literature, so the score was as many times as the method was cited.

Causes of Math Anxiety

The top two factors causing math anxiety were tied with four citations each. The first of these discussed in this paper is timed tests. According to Ashcraft and Moore (2009); Hopko et al. (2003a); Jackson and Leffingwell (1999); and Tobias (1978), the stressful situations that timed tests puts students under induces math anxiety and negatively affects their math performance.

The second factor that is tied for the leading cause of math anxiety is instructional methods. According to Hopko et al. (2003a); Jackson and Leffingwell (1999); Oberlin (1982); and Tobias (1978), traditional teaching methods like rushed explanations; assigning long, drill and kill homework every night, especially as punishment; there is only one right answer; lecturing; and the teacher doing complicated mathematical computations on the board cause math anxiety.

The second leading cause of math anxiety with three citations is teachers' attitudes. According to Hembree (1990); Jackson and Leffingwell (1999); and Tobias (1978), attitudes portrayed by teachers that are uncaring, angry, and biased are factors causing math anxiety.

Tied for the third leading factors causing math anxiety are students' attitudes and materials with one citation each. The first of these is students' attitudes that are negative and self-confidence and self-concept of mathematics is low (Hembree, 1990).

The next factor tied for third leading cause of math anxiety is materials. Difficult materials or mathematical concepts that are not fully explained or understood by students is a cause of math anxiety (Jackson & Leffingwell, 1999).

Methods of Reducing Math Anxiety

The top method to reduce math anxiety with six citations is to have the students discuss their feelings about math anxiety, past and present, in a productive way either verbal or written (Furner & Duffy, 2002; NCTM, 2000; Shodahl and Diers, 1984; Stuart, 2000; Swanson, 2013; Tobias, 1991; Tobias, 1978). Verbal can be options like a group discussion in an environment similar to counselling or an audio journal. Written examples are writing in a journal or write down feelings next to the mathematical problem the students are working through.

Anxiety management techniques with five citations is the second leading method to reduce math anxiety. Techniques such as taking deep breaths, relaxation, systematic desensitization, and self-talk are found to help students manage their math anxiety (Hembree, 1990; NCTM, 2000; Shodahl and Diers, 1984; Swanson, 2013; Tobias, 1978).

Tied for the third leading are three math anxiety reducing methods with three citations each. The first of these is students' attitudes. By increasing the students' enjoyment in mathematics those negative attitudes found to cause math anxiety are turned into positive attitudes which reduce that math anxiety (Hembree, 1990; Stuart, 2000; Tobias, 1991).

The second method of the tie for third leading math anxiety reducing methods is instructional methods. According to Jackson and Leffingwell (1999); Shodahl and Diers (1984); and Stuart (2000), instructional methods to reduce math anxiety include: being more flexible and offering more preparation time for exams; allowing more time for students to grasp the

mathematical concept; making mathematics relevant; incorporating more class subject; and using hands-on, visual representations.

Bibliotherapy is the last method to reduce math anxiety in the tie for the third leading method. Bibliotherapy helps students to reduce their math anxiety by giving them a character in the book that they can relate their math anxiety with (Furner & Duffy, 2002; Hébert and Furner, 1997; NCTM, 2000). The students then know they are not alone with their math anxiety. They begin to discuss and express their frustrations with mathematics which allows them to move past the feelings and understand the mathematics.

The fourth, and final method to reduce math anxiety is teachers' attitudes with two citations. When teachers portray positive, helpful, and caring attitudes towards their students and mathematics it helps to reduce students' math anxiety (Jackson & Leffingwell, 1999; Shodahl and Diers, 1984).

Every student learns differently and every teacher teaches differently. Likewise, every students' case of math anxiety it different. This paper lists the top five factors that cause math anxiety (timed tests, instructional methods, teachers' attitudes, students' attitudes, and materials) found in her research, but there are many more out there. Teachers of secondary mathematics can avoid these factors in their classrooms to make an environment that does not provoke math anxiety. Also, this paper lists six categories of methods to reduce math anxiety (expressing feelings, anxiety management techniques, students' attitudes, instructional methods, bibliotherapy, and teachers' attitudes) found in her research, but more could be out there and frequently more research is added to this subject. Each student is unique and the way to reduce their math anxiety will be unique, but by applying these methods a teacher can help multiple students overcome their math anxiety. With this paper, the author wants to educate teachers of

the upper grades about the most effective strategies of how to reduce math anxiety at one of the most pivotal moments in students' lives. With those strategies we can shed a better light on the subject of mathematics and enhance the educational and career opportunities for students.

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