ABSTRACT

KIDD, JANICE SEATE. The Effects of Relational Teaching and Attitudes on Mathematics Anxiety. (Under the direction of Karen S. Norwood.)

While mathematics anxiety continues to affect people of all ages, researchers continue to look for effective methods of reducing it. This thesis provides a brief introduction to mathematics anxiety, including background, and causes and preventions according to experiences researchers and educators have had. The main purpose of this thesis is to look at research on the effectiveness of relational teaching as a means for reducing mathematics anxiety. Research on teachers' attitudes and how they affect students' attitudes toward mathematics as well as students' mathematics anxiety is also examined.

Evidence from available studies on relational teaching and its effectiveness at reducing mathematics anxiety indicated inconclusive results. Furthermore, evidence from available studies on teacher attitudes and their effects on students' attitudes toward mathematics and their mathematics anxiety indicated inconclusive results as well.

THE EFFECTS OF RELATIONAL TEACHING

AND ATTITUDES ON MATHEMATICS ANXIETY

by

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DEDICATION

I would like to dedicate this thesis to my husband, Kevin, and to my parents, Jimmy and Sara. Without all of their love, encouragement, and support I know I could not have accomplished this task. They have always been there for me and are blessings in my life.

BIOGRAPHY

Janice Seate Kidd was born in Durham, North Carolina. Her parents, Jimmy and Sara Seate, still live in the house Jan's family moved in when she was in the sixth grade. She has one brother, Jamie, who is five years older than Jan. Jamie lives with his wife, Amy, and his stepdaughter, Augusta, in Holly Springs, North Carolina. Jan loves the fact that she and her brother live only five minutes away from each other.

Jan attended elementary school, junior high school and high school in Durham. She enjoyed growing up with a mom as a teacher and always being able to spend her summers with her mom. She graduated from Northern Durham High School in 1994 and went on to attend Meredith College in Raleigh, North Carolina. At Meredith, Jan was a North Carolina Teaching Fellow. In 1998, Jan graduated Magna Cum Laude from Meredith with a major in mathematics, a minor in English, and teaching certification in grades 6-9.

While at Meredith, Jan did her student teaching at Davis Drive Middle School in Cary, North Carolina—sixth grade mathematics. She was lucky enough to be hired for the next year as a sixth grade mathematics teacher. Jan has been at Davis Drive for five years and loves her job tremendously. She truly enjoys passing on mathematics to her sixth graders and constantly focuses on teaching her students in ways in which they will obtain true, meaningful understanding of the concepts.

In the fall of 1999, Jan decided to go back to school to further her education. She was accepted into the graduate program at North Carolina State University and began the long process of taking just one class a semester while still teaching. Jan has found her experience at NCSU to be beneficial. She especially feels she has become a better teacher due to the classes she has taken and the professors she has encountered.

Jan looks forward to a future of teaching mathematics to middle school students. She and her husband currently live in Apex, North Carolina.

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LIST OF ABBREVIATIONS

MARS…………Mathematics Anxiety Rating Scale

MARS-A……….Mathematics Anxiety Rating Scale for Adolescents

MARS-E………..Mathematics Anxiety Rating Scale for Elementary School Students

MASC…………..Mathematics Anxiety Rating Scale for Children

MAS…………….Mathematics Anxiety Scale

CHAPTER 1

Introduction

Chapter one of this thesis is divided into four main sections. The first part is an introduction to mathematics anxiety, which includes definitions, characteristics, descriptions, and background. This information is included because it is important for the reader to have a basic understanding of mathematics anxiety. More importantly, this section of chapter one identifies the research questions that are the primary focus of this thesis. The second part of chapter one deals with the causes of mathematics anxiety and specifically focuses on mathematics myths, classroom experiences/attitudes, teaching methods, and family attitudes, which contribute to mathematics anxiety. The third part of chapter one addresses preventions. It is here that interventions, teaching methods, and family are discussed as methods for preventing mathematics anxiety. Causes and preventions are included in order for the reader to understand what researchers and educators are saying about mathematics anxiety. Lastly, instruments used to measure mathematics anxiety are described--the purpose being to specifically describe common instruments used in studies about mathematics anxiety so that the reader will have a better understanding of the studies' methodology.

Introduction

Mathematics anxiety is the subject of Math Curse (Scieszka & Smith, 1995), a popular children's book. Fun and humor are incorporated into this book; however, mathematics anxiety is anything but fun and humorous to thousands of people. In the book a dream--after a day of being cursed with grueling mathematics--is the cure for the girl's mathematics anxiety. In reality, however, it should be so simple. From the second grader who cannot understand the concept of place value to the high school algebra student who dreads the moment the teacher calls on him for an explanation to the mathematics teacher who is fearful of math, mathematics anxiety, "without treatment, seems to stay with the victims throughout their entire lives" (Greenwood, 1984, p. 662).

Richardson and Suinn (1972) state mathematics anxiety "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Another definition, according to Tobias and Weissbrod (1980), claims mathematics anxiety is "the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (p. 65). Mathophobia, a synonym for mathematics anxiety according to Williams (1988), is described by Lazarus (1974) as an "irrational and impeditive dread of mathematics" (p. 16). Hodges (1983) asserts frustration in mathematics stems from failure in mathematics. As a result, students develop mathematics anxiety. One of the results of mathematics anxiety is an illness called mathophobia (Hodges, 1983, p. 17).

No matter which of the many definitions is used to describe it, mathematics anxiety is most definitely a problem for many people. Researchers and educators alike have offered various reasons for this anxiety, from negative teacher experiences to lack of family support. Likewise, these same people have offered suggestions for preventing or reducing mathematics anxiety, from thinking more positively about mathematics to relaxation methods to acquiring better mathematics study skills. While all of these suggestions may sound plausible and may indeed prove to be successful in the case of preventing or reducing mathematics anxiety, many of them have no validity; there is no research to back up whether or not these suggestions help to alleviate mathematics anxiety. It seems, in fact, that research on mathematics anxiety is limited. Therefore, it is imperative to understand what research has been conducted in order to begin to help people overcome their mathematics anxiety. Through validated research, this goal can begin to be met.

It seems that fear of numbers and all-around anxiety toward mathematics have increasingly become a significant educational issue over the past thirty years (Greenwood, 1984; Williams, 1988). In light of how mathematics anxiety can affect a person's self-esteem and worth, it is of utmost importance to implement meaningful interventions for reducing mathematics anxiety. Therefore, as educators and as society, it is crucial to discover ways mathematics anxiety can be reduced. The focus of this thesis is to evaluate, through past research, the overall classroom climate and how it relates to mathematics anxiety. More specifically, this evaluation will attempt to address two questions. Does relational teaching (teaching in which students take a more active, hands-on role in their mathematics learning) reduce mathematics anxiety and do teachers' attitudes in the classroom (expressed verbally and nonverbally) affect students' attitudes toward mathematics as well as their mathematics anxiety? In terms of attitudes, it is important to understand that this thesis focuses on teachers' overall demeanor in the classroom. Negative verbal responses to students are included in this demeanor. This means inappropriate words spoken to students or appropriate words spoken to students in a negative tone. Nonverbal responses like sighing and having his or her arms crossed in frustration are also considered part of this demeanor. However, this thesis focuses on positive teacher attitudes as well, in which teachers praise and encourage students throughout the mathematics class. Throughout the studies on attitudes in chapter two, other factors besides teacher attitudes are discussed as influences on students' attitudes toward mathematics and their mathematics anxiety. However, teacher attitudes are the primary focus in this thesis.

According to Zaslavsky (1994), although mathematics anxiety has more than likely existed for hundreds of years, this syndrome where people believe they cannot do mathematics became an interest to educators during the feminist movement of the 1970's. Many high school girls during this time were not taking the needed mathematics classes in order to put them on the track to promising careers with handsome salaries. Tobias (1978) says, ". . . women are predestined to study certain subjects and pursue certain occupations not only because these areas are 'feminine' but because girls are socialized not to study math" (p. 12). As a result of the awareness of mathematics anxiety by researchers like Tobias, the hush-hush thoughts and ideas about being afraid of mathematics—for men and women—were being addressed. Finally, instances where people were avoiding keeping score in card games, assuming the car salesman's numbers were correct, and declaring history as a major in order to dodge more mathematics classes were being thought of as "okay" things to do because now an explanation existed.

Since the awareness of mathematics anxiety in the 1970's, Elliott (1983) claims three specific types of math-anxious people exist—the mathematics memorizer, the mathematics avoider, and the self-professed mathematics incompetent. Elliott says non-creativity is associated with the mathematics memorizer. Math memorizers, according to Wheatley (1977), look for an algorithm to solve mathematics problems. When one cannot be identified, the mathematics memorizer assumes the problem is unsolvable. Due to the constant looking for an algorithm, the mathematics memorizer never gives the creative part of the mind a chance to work. Resulting from this constant occurrence of denying creativity is the psychopathology of non-creativity.

Negativism is associated with the mathematics avoider, according to Elliott (1983). The mathematics avoider has failed in mathematics in the past, and therefore predicts future failures. This type of mathematics anxious person creates a self-fulfilling prophecy because of the constant attention to believing failure will occur. Motivation and drive are destroyed due to the negativism. As a result, these people do not do well in mathematics, which leads to the avoidance of taking more mathematics classes in the future.

According to Elliott (1983), low self-esteem is associated with the self-professed mathematics incompetent. Continuously encountering mathematics problems that cannot be solved truly affects the egos of some people. The self-professed mathematics incompetent feels he or she is the only one to blame for not being able to do mathematics—that something is wrong with him or her and never think other people or instances might be the culprit of their anxiety. As their self-esteem plummets, more mathematics anxiety is created and their confidence lessens. Martinez (1987) claims symptoms of a mathematics anxious person include turning in math assignments late, asking to be excused frequently from class, and saying negative things about mathematics. Feelings and thoughts about mathematics anxiety, according to Aksu and Saygi (1988), include tension, panic, helplessness, fear, distress, shame, and the inability to cope. Arem (2003) adds that mathematics anxious people can feel disorganized, confused, insecure, as well as experience shortness of breath, muscle tightness, or physical sickness.

Causes

This section discusses causes of mathematics anxiety that have been identified by researchers and educators that include mathematics myths, classroom experiences and/or attitudes, teaching methods, and family. Although some of this information is based on research, much of the information included in this section is based on experiences researchers and educators have had. Tobias (1978) claims the purpose of her book, *Overcoming Math Anxiety,* is "to convince women and men that their fear of mathematics is the result and not the cause of their negative experiences with mathematics, and to encourage them to give themselves one more chance" (p. 15). In order for mathematics anxious people to give themselves one more chance, it is important to fully understand exactly how people develop mathematics anxiety. If the causes of mathematics anxiety can be pinpointed, then it is more likely that effective preventions can be implemented.

Mathematics Myths

Misconceptions about mathematics, or math myths, seem to be one of the causes of mathematics anxiety. Zaslavsky (1994) claims mathematics taught in school is very responsible for many of these mathematics misconceptions. If these myths stem from school, it seems likely mathematics anxiety can infect a student at a very young age. The influential myths Zaslavsky identifies includes the following: every mathematics problem has just one right answer; mathematics is hard and only a genius can understand it; never count on fingers or use hands-on materials to help solve a mathematics problem; and you have to follow the procedures the teacher and textbook give you when doing mathematics. Tobias (1978) notes another mathematics myth that says either a person has or does not have a mathematical mind. And Taylor and Brooks (1986) note an extremely common myth that says males are better at mathematics than females.

These mathematics myths can be detrimental to a person's ability to learn mathematics. For instance, if a student believes there is just one right answer to a mathematics problem and no manipulatives can be used to solve that problem, then it could be quite easy for a student to give up after a few unsuccessful attempts. Giving up in frustration may eventually lead to a feeling of failure. This thinking can be further reinforced when the teacher forces the student to follow exactly his or her procedures. When this happens, many times the teacher will count a problem incorrect if the student solves the problem differently from the procedure taught. Therefore, the pressure of successfully and "correctly" finding that one right solution may certainly lead to mathematics anxiety. As a result, students may avoid mathematics altogether. Furthermore, students who believe only geniuses can understand mathematics and that either a person has or does not have a mathematical mind can often succeed in some parts of mathematics and still maintain a negative outlook on mathematics—all due to these mathematics myths. Tobias (1978) explains the thought process a student goes through:

> Since only a few people are supposed to have this mathematical mind, part of our passive reaction to difficulties in learning mathematics is that we suspect we may not be one of "them" and are waiting for our nonmathematical mind to be exposed. It is only a matter of time before our limit will be reached, so there is not much point in our being methodical or in attending to detail. We are grateful when we survive fractions, word problems, or geometry. If that certain moment of failure hasn't struck yet, then it is only temporarily postponed. (p. 47)

In addition, the myth that males are better at mathematics than females can be quite detrimental to young girls whose self-concept and self-esteem are developing. Girls who see the boys with their hands up and being called on all the time may feel intimidated. Early on girls may begin to feel that no matter how hard they try boys are better at mathematics. Even girls who do well in mathematics may start to contribute their success to their hard work and not their intelligence. This line of thinking may cause girls to forever be intimidated by boys in terms of mathematics—ultimately affecting the types of mathematics classes girls take and even their careers.

It is important for students who believe in these myths to rethink their beliefs. Thinking positively and knowing more about what it means to understand and learn mathematics is essential. Students should realize that there are often many methods for solving a mathematics problem and that drawing a picture or counting fingers is an acceptable means for finding a solution. If geniuses are the only people who can do mathematics, then there must be a multitude of geniuses around, and we know that is not the case. And if males are better than females at mathematics, then why are there so many female mathematics teachers, female accountants, and female statisticians? Common sense indicates these myths hold no real value.

Classroom Experiences/Attitudes

Negative classroom experiences—especially experiences directly involving the teacher—seem to be a source of mathematics anxiety (Williams, 1988; Taylor & Brooks, 1986). It seems just one bad experience with a teacher can put a student on the road to mathematics anxiety. If a teacher does not get excited about mathematics, is fearful of certain topics that must be covered in the curriculum, or appears frustrated and angry, then students may pick up on these vibes, which can directly affect them. One student pinpoints a specific negative mathematics experience in the following:

> I remember very clearly my first experience with numbers and addition, and it was not a positive one. My kindergarten teacher, Mrs. Sonders, had auburn hair and wore bright red lipstick. I can't remember her ever smiling. It is my belief today that this woman had no business teaching anybody anything. We were given sheets of paper and told to draw a certain number of circles and then to add another number of circles. She walked by and pointed at my paper and with an angry voice said I was wrong. My mom was called, and the next day she came in for a parent-teacher conference. I felt embarrassed as I swung on the jungle gym outside, while Mrs. Sonders spoke with my mom in the classroom. I knew they were talking about my circles. That's when I began hating math. (Arem, 2003, p. 24)

It is not uncommon for these experiences to begin in elementary school. Hackworth (1985) claims that most mathematics anxious people who remember these school experiences claim they occurred in elementary school when learning fractions. Few of the mathematics anxious people claim it began in junior high, though some say their mathematics confidence was pretty good until they took algebra or geometry. If mathematics anxious students did not become anxious in elementary or junior high schools, they often did in college due to a first course in calculus.

Hackworth identifies three mathematics topics studied in school that seem to be "stumbling blocks" (p. 8): fractions, algebra or geometry, and calculus. He claims one reason for this could be the teachers' attitudes when teaching these particular concepts. Hackworth says,

> Elementary school teachers, especially when approaching the teaching of fractions, often express a fear or dislike of mathematics. Secondary teachers of algebra and geometry frequently see their subjects as being of a far higher status than the preceding elementary school arithmetic. Calculus teachers, too, often treat their subject with a reverence and an

> awe that communicates a belief that calculus can only be achieved by exceptional minds. (p. 8)

Tobias (1978) agrees. She says if a mathematics teacher always portrays a happy and successful time with mathematics, especially when he or she was in school, then students may feel inferior. If the teacher seems to be gifted in mathematics, according to Tobias, students may feel that they will never be as good as their teacher.

Teaching Methods

Some of the teaching methods of mathematics teachers seem to also contribute to students' mathematics anxiety (Greenwood, 1984; Martinez, 1987). Steele and Arth (1998) say often students' attitudes toward mathematics are positive and mathematics is enjoyable until the fourth grade. Mathematics anxiety starts to emerge in many students due to the explain-practice-memorize teaching approach, according to Steele and Arth. After fourth grade, many teachers begin to implement pencil-and-paper teaching methods, as well as more written assessments. As a result, teachers use this same teaching cycle over and over to teach the curriculum. Steele and Arth say this all too common cycle includes explaining how to do the problems, doing the problems, memorizing the formula/algorithm for the problems, correcting the problems, and assessing whether or not the problems are understood through a test. Steele and Arth believe this cycle is a leading source of mathematics anxiety.

A significant part of the explain-practice-memorize teaching method is the lack of making connections. If teachers, according to Steele and Arth (1998), are not relating mathematics to real life, then students have a difficult time connecting mathematics to anything relevant. Taylor and Brooks (1986) state, "When students can relate mathematics to their daily lives, they begin to relax and to develop an interest and enjoyment in mathematics" (p. 1). According to Steele and Arth (1998), when relationships are not made, students spend much of their time learning and practicing mathematics concepts they do not truly understand. Because students cannot connect mathematics to anything, they turn to memorization as a survival tactic. As a result of memorizing pieces of information here and there, mathematics makes no sense to students and the road to becoming anxious is now open. Steele and Arth say students begin to feel as if memorizing is their only way to succeed in mathematics. It does not take long for students to realize memorization is not the key to success in mathematics and, therefore, start to fear and avoid mathematics.

Skemp (1976) calls this idea of making connections relational understanding—"knowing what to do and why" (p. 20). He claims another kind of understanding exists called instrumental understanding in which he describes as "rules without reasons" (p. 20). Skemp supports promoting relational understanding in the classroom.

Skemp (1976) claims instrumental understanding is the type of understanding in which students *memorize* what methods work for certain problems and what methods do not. He notes that students who learn instrumentally learn in a way "by which pupils can find their way from particular starting points (the data) to required finishing points (the answers to the questions)" (Skemp, 1976, p. 25). Mathematics anxiety often occurs as a result of instrumental learning because an understanding of the material is not obtained—only memorization. Without some meaning attached to what was memorized, the information will not be retrieved easily or at all. Therefore, memorization becomes just a temporary way to do well on an assignment and nothing is truly understood or learned.

Skemp compares instrumental learning to children taking a music class in which they learn through pencil-and-paper. For instance, they learn that a minim is a line with an open oval and that the marks on the lines of the stave are called E, G, B, D, and F. However, these children would never *demonstrate* these ideas through instruments or other sounds. Skemp claims that while these children would be knowledgeable about music on paper, they would become bored and would likely not pursue music.

On the other hand, Skemp (1976) describes relational understanding as the process of building up of a "conceptual structure (schema) from which its possessor can (in principle) produce an unlimited number of plans for getting from any starting point within his schema to any finishing point" (Skemp, 1976, p. 25). Relational understanding means students understand how many concepts are inter-related as parts of a connected whole. Children who are taught music relationally would be able to associate certain sounds with the marks on their paper. Furthermore, Skemp adds:

> For the first few years these are audible sounds, which they make themselves on simple instruments. After a time they can still imagine the sounds whenever they see or write the marks on paper. Associated with every sequence of marks is a melody, and with every vertical set a harmony. The keys C major and A major have an audible relationship, and a similar relationship can be found between certain other pairs of keys. And so on. Much less memory is involved, and what has to be remembered is largely in the form of related wholes . . . . (p. 22)

Greenwood (1984) believes that instrumental teaching is a primary cause of mathematics anxiety (p.663). He includes the explain-practice-memorize teaching strategy as a form of instrumental teaching and says the following:

> This teaching methodology, by its nature, isolates facts from reason and from the process of problem solving itself. It concentrates on the procedures for producing answers and is not particularly concerned with the development of logical thought processes nor with the type of

> mathematical reasoning that is at the basis of our computational algorithms and our more abstract symbolic transformation. (Greenwood, 1984, p. 663)

Based on qualitative interviews with teachers all over the country, Seymour (1996) described effective mathematics instruction as "learning in action" (p. 43). This means incorporating games, simulations, problem-solving activities, discoveries, and challenges in teaching strategies. By using these manipulatives and real-life scenarios, these teachers claimed mathematics became more meaningful to their students.

This is also supported by Dutton and Dutton (1991) who discovered that when mathematics is taught without an emphasis upon understanding, without real-life connections, and with a focus on paper-and-pencil drills, then teachers and students begin to dislike mathematics. Therefore, Dutton and Dutton encourage the use of manipulatives for learning mathematics. In addition, Grouwns (1992) claimed mathematics anxiety can be greatly reduced by using concrete materials.

Tittle and Denker (1981) discuss a project that was designed to evaluate a mathematics anxiety reduction program called TEAM (Chapline and Newman, 1980). This program was designed for undergraduate students studying to be elementary school teachers. One component of TEAM was to reduce mathematics anxiety and increase confidence through certain relational activities. After evaluating for the instructional approach—generalizing problem-solving rules instead of being given a set of rules--when teaching mathematics, Tittle and Denker (1981) say the following:

> The philosophy underlying the teaching strategy used in the TEAM materials is that confidence and knowledge of the learner are best enhanced by the use of an inductive approach. In this approach, learners are not given the problem solving rules immediately, but arrive at them through generalizing from the solutions to a number of carefully selected and sequenced problems. As indicated by the student logs and open-ended

> responses, the approach was fruitful in terms of the learners' ability to reconstruct formulas, to feel "comfortable" during examinations, and to feel more confident about math. (p. 7)

Family

It seems the family has a part in the development of mathematics anxiety, as well (Schwartz, 2000). Schwartz says, many parents, either directly or indirectly, support another common myth that says being successful in mathematics is something with which person is born. It is not uncommon to hear a parent say he or she was never good in mathematics, which explains why the child struggles.

Tobias (1978) also claims that the New Math of the 1960's introduced a new mathematics vocabulary. As a result, mathematics texts were rewritten and elementary teachers were now going to clinics to help them understand these changes. During this time, parents were encouraged to take a crash course in the New Math so they would be able to help their children at home. Tobias says this caused problems. If a parent had never taken advanced mathematics in college or did not try to learn the New Math, then the child would get no support from home. She claims, "How can you help a child who talks about 'sets' when you have never heard of them and the child says *you* don't know what the teacher is doing?" (p. 33-34). Tobias also claims students' unsatisfactory performance in mathematics could be the result of their lack of support at home.

On the other hand, Arem (2003) says parents' lack of support is not the only way family can contribute to mathematics anxiety. Some parents push their children too much to succeed in mathematics. Arem describes a girl whose father tutored her and went over her homework every night. He would get very frustrated with her if she did not catch on fast enough and would slam the book closed. As a result, the girl started to avoid taking mathematics classes in high school because she was afraid of not pleasing her father. Arem also says comparing one child to a sibling who is very successful in mathematics can also cause anxious feelings about mathematics (p. 16).

Preventions

This section on preventions discusses interventions, teaching methods, and family. Researchers and educators have spent a great deal of time focusing on the causes of mathematics anxiety. While these causes are extremely important to understand, it is also important to find ways to prevent mathematics anxiety—or in the very least, ways to lessen its effects. The next section discusses preventions of mathematics anxiety described by researchers and educators. Some of the same topics from the previous section, such as teaching methods and family, are discussed. However, they are discussed in terms of *preventions.* After all, if a particular teaching method causes mathematics anxiety then another teaching method may prevent mathematics anxiety. Preventions discussed are broken down into interventions (positive attitudes, positive mathematics experiences, and creating success), teaching methods, and family preventions. Again, this information is not necessarily based on studies, but is the opinions and conclusions of researchers and educators.

Interventions

Positive attitudes seem to play a key role in the prevention of mathematics anxiety (Arem, 2003; Taylor & Brooks, 1986). According to Martinez (1987), "The pressure is on for American students to learn more math and to learn it more quickly . . . students must want to learn math, feel good about learning math, and be confident that they can learn math" (p. 125). Arem (2003) agrees and suggests a strategy for conquering mathematics anxiety that involves having a positive mathematics attitude. Arem says,

> The belief in success is the one great driving force behind all successful students. Believe you will succeed in reaching your math goal and you will! Having a positive belief creates the energy, the momentum, and the means needed to accomplish your goal. It fills you with vitality and vigor to charge ahead and to creatively deal with any obstacle that enters your path. (p. 59)

Arem (2003) suggests two strategies for helping develop a positive mathematics attitude. The first is an exercise on *rewriting* disempowering mathematics beliefs. In this exercise, common math myths are listed, and each myth must be countered so that it turns into a reasonable positive belief (see Figure 1).

Disempowering Math Belief	**Reasonable Math Belief**
1. Math should come easily to me.	Mathematicians work hard at doing math, so why should it come easily to me?
2. There's a right way to do math.	**There are lots of okay ways to do anything, including math.**
3. No one in my family ever succeeded in math, so why should I?	I'm an intelligent and capable person; I've succeeded in a lot of things in my life; why not math?

Figure 1. Sample of Rewriting Disempowering Math Beliefs by Arem (2003, p. 59-60).

The second suggestion Arem (2003) has for developing a positive mathematics attitude is for anxious people to act on their mathematics rights. When these rights are evaluated, changed to suit the mathematics anxious person, and used with good judgment, the mathematics anxious person's attitude toward mathematics will also become more positive. Arem identifies the following as math rights: having the right to ask "why;" having the right to say, "I don't know" or "I don't understand;" and having the right to make mistakes in math and learn from those mistakes (p. 61-62).

Along with positive mathematics attitudes are positive mathematics experiences. This includes a positive learning environment. The environment in which students learn is important, and Williams (1988) suggests mathematics teachers provide a classroom in which students feel comfortable. Teachers need to closely examine their reactions to students and others' reactions as well, for criticizing should not take place. If any of these reactions are negative, Williams says a change in the classroom environment needs to occur (p. 101). Steele and Arth (1998) agree. They claim teachers have to be extremely careful in the manner in which they ask for correct answers. Steele and Arth suggest teachers never single any student out; instead, ask for volunteers. Also, if students are struggling with a problem, teachers need to encourage them to not give up. Steele and Arth say to point out to the students the positive things they are doing to solve the problem. Reinforce to the students the difference in giving up and taking a break from a difficult problem. Williams (1988) adds that teachers need to be familiar with mathematics strengths and weaknesses of each student. She also says teachers can help weaker mathematics students feel successful by giving them assignments that will more than likely guarantee them a success.

Arem (2003) believes another way to reduce or prevent mathematics anxiety is by creating success. She adamantly supports having a strong, positive belief system—especially for the mathematics anxious. Arem claims,

> Beliefs can be very empowering in our lives. They tap into the richest resources deep within us. It is belief that activates your mind to find constructive ways and alternatives to reach your goals. Develop a positive belief system about math and success is sure to follow. Negative beliefs stop you in your path. (p. 59)

Arem has a mathematics success plan she suggests for the mathematics anxious (see Appendix A). She provides an exercise that contains nine different sections—all of which pertain to goals for success. A description of the nine parts follows: 1) identify mathematics goal; 2) target date; 3) evaluate strength of goal; 4) identify benefits from accomplishing goal; 5) identify obstacles; 6) identify positive forces; 7) list supportive people; 8) know willingness to reach goal; and 9) identify rewards. Arem encourages mathematics anxious people to know exactly what their mathematics goals are. In reference to goals, Arem explains:

> We must toss them out in front of us and then use them to pull ourselves along. In this way, you take control of your math future. Your math success will happen by your design and not by chance. You *can* have the math success you want! (2003, p. 4-5)

Teaching Methods

Some teaching methods are discussed as causes of mathematics anxiety in the earlier part of chapter one. However, different teaching methods are now going to be discussed as preventions of mathematics anxiety. Teaching methods used in a mathematics classroom seem to have an effect on mathematics anxiety (Greenwood, 1984; Lazarus, 1974). Greenwood (1984) suggests that mathematics anxiety is "a problem whose solution lies almost entirely within the domain of mathematics education" and that the "major source of math anxiety lies in the impersonal, nongrowth, nonrational methodologies that are characterized by the 'explain-practice-memorize' paradigm" (p. 663). In support, Williams (1988) claims teachers should accommodate various learning styles. She says those students who learn best through a tactile and/or kinesthetic approach will learn more meaningfully through manipulative aids (p. 101).

Arem (2003) agrees with Williams in that by knowing and understanding what learning style a person has can have positive effects. Arem explains:

> Learning styles can make a big difference in your life. By understanding and working with your unique learning style, you can greatly enhance your math achievement. You'll study better, feel more excited about learning math, and your test scores will be higher. What's more, you'll feel a greater measure of self-control. (2003, p. 77)

Arem (2003) notes three prominent perceptual learning channels and claims knowing which one(s) work best can significantly affect the way a person learns and recalls mathematics. The three perceptual learning channels are visual, auditory, and kinesthetic/tactile, and she offers an assessment for the purpose of identifying a person's correct perceptual learning channel (see Appendix B). Visual learners learn best by seeing mathematics written down. These learners stay focused by looking at the teacher at all times. Auditory learners learn best by hearing mathematics being explained. These learners prefer to listen and not take notes. Kinesthetic/tactile learners learn best through hands-on mathematics experiences. These learners must do the problems themselves—watching others does not help. Once a person knows and understands the learning styles, teachers should use the knowledge to help students learn mathematics more meaningfully; thus, avoiding the explain-practice-memorize cycle.

Williams (1988) says teachers also need to make a conscious effort to make mathematics relevant to students (p. 101). Steele and Arth (1998) support this notion and claim learning conceptually aids in being able to relate mathematics to everyday situations. Therefore, Steele and Arth suggest activities, such as designing a birdhouse with all the correct dimensions and figuring out how much the materials will cost, in order to instigate this relationship. Likewise, Stuart (2000) relates mathematics to other subjects in her classroom. By doing this, students who enjoy science, social studies, writing, etc., can incorporate mathematics—a subject they are anxious about—into them. Stuart feels relating other interesting subjects to mathematics can make a big difference in the understanding of mathematics. Some examples include using mathematics to calculate results from a science experiment, drawing maps to scale in geography, calculating the differences in dates on a timeline in social studies, and applying mathematics skills through technology. Stuart says incorporating mathematics into other subjects boosts "students' confidence by providing meaningful contexts for their work" (p. 335).

National Council of Teachers of Mathematics (NCTM, 1995) sums up much of the suggestions given to teachers in order to help reduce mathematics stress and anxiety in the classroom (see Figure 2).

Practices to Reduce Math Anxiety

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.

Figure 2. Practices to reduce math anxiety by NCTM (1995).

Furthermore, a paraphrased Chinese proverb states the following:

> Tell me mathematics and I will forget; show me mathematics and I may remember; involve me in a tension-free atmosphere in small group work and with manipulative aids in mathematics and I will understand. If I understand mathematics, I will be less likely to have math anxiety, and if I

> become a teacher of mathematics I can thus begin a cycle that will produce less math anxious students for generations to come. (Williams, 1988, p. 101)

Family

Family is also discussed earlier in chapter one as a cause of mathematics anxiety. In this section, ways family can help prevent mathematics anxiety are discussed. According to Burns (1998), family attitudes can help reduce or prevent mathematics anxiety. She claims if parents spent as much quality time with their children on mathematics as they do reading, children would truly benefit. Children need quality mathematics learning and they need it done correctly. Burns advises parents to not make reference to hating mathematics or not being good at mathematics or claiming the reason for the struggle is because another family member was never any good at mathematics. Hearing these excuses might give the child a reason for not putting in any effort. Burns points out parents need a positive attitude that hints at mathematics curiosity and that leans toward learning *together*. Burns encourages parents to look at their child's mathematics frequently and to have children tell parents what they have learned.

Another suggestion Burns (1998) has for parents is to let children see them doing mathematics. For instance, when a child sees a parent balancing a checkbook, the child is witnessing adding and subtracting of money. When a child sees a parent read a map, the child is seeing first-hand how to read a scale and apply it to find distances between places. Children who help their parents cook understand that estimating the amount of some ingredients is appropriate and that measuring others is better. Also, if parents really enjoy reading with a child, Burns points out that many children's books exist that deal solely with mathematics. Burns claims the following:

> There’s no one right or best way to support math learning, or any learning, for that matter. You’ll have to tinker with what works for you and for your children. But doing nothing has zero chance of helping, and that’s a math concept we all understand. (1998, p. 135-137)

Zaslavsky (1994) supports parental involvement in mathematics learning. When children are especially young, parents have great opportunities to help foster and develop mathematics attitudes and learning. She emphasizes that parents have the ability to boost their child’s self-esteem. Children will do much better in school and mathematics the earlier parents begin their interventions. Also, it is crucial to intervene as soon as a child falls behind as well. Zaslavsky says a great way to get children involved in mathematics at home is through games. The nice part about playing games is that formal mathematics is not needed to play games involving math. Zaslavsky sums up the idea of the home being such an influential learning environment:

> The home is the world’s largest and best school system. Parents as teachers are not burdened with twenty or thirty students, nor are they regulated by school bells and administrative duties. Home is the ideal setting for children to learn attitudes and concepts, how to ask questions, how to seek and verify knowledge. Learning how to find answers is a skill that will serve for a lifetime. (1994, p. 200).

Instruments

The next section is about the instruments used by researchers to measure mathematics anxiety and mathematics attitudes for their studies. While several of the instruments are seen in more than one study, some are only found in one study. These instruments determine things like how much anxiety a person has toward mathematics or a person’s attitude toward mathematics. A popular instrument discussed in the studies found in chapter two is Mathematics Anxiety Rating Scale (MARS). Versions of MARS that have been modified for certain populations are also found in chapter two. These include Mathematics Anxiety Rating Scale for Adolescents (MARS-A), Mathematics Anxiety Rating Scale for Elementary School Students (MARS-E), and Mathematics Anxiety Scale for Children (MASC). Another common instrument seen in chapter two is the Fennema-Sherman Mathematics Attitudes Scales which includes the Mathematics Anxiety Scale (MAS). Other instruments in chapter two are the Mathematical Self-Concept Scale and the Beliefs About Mathematics Scale. It is important to understand these instruments in order to better understand the studies and exactly how results were determined.

MARS

The Mathematics Anxiety Rating Scale or MARS is a popular instrument used in many of the studies, and is intended to be administered to college students or adults in general. According to Richardson and Suinn (1972), MARS was "constructed to provide a measure of anxiety associated with the single area of the manipulation of numbers and the use of mathematical concepts" (p. 551). MARS can be used in treatment or research and is beneficial to people who are conducting research specifically about mathematics anxiety. There are 98 items on this scale—each item a brief description of a mathematical situation that may cause a level of anxiety in a person. The questions are suited for both students and nonstudents. Each of the 98 items is rated from 1 to 5 with 1 being *not anxious* and 5 being *very anxious*. A final score is determined by adding all the responses together. The higher the score the higher the level of mathematics anxiety.

In order to determine the reliability and validity of MARS, Richardson and Suinn conducted a study. The sample population included 397 freshmen and sophomores enrolled in beginning education classes at a Missouri university. Though the sample included mostly females, it was determined that there was no significant difference between the mean scores or standard deviations from MARS for males and females. Two of the classes (n = 35) were retested 7 weeks later in order to obtain the reliability data. These students were told to base MARS on how they currently felt, seven weeks after first taking it. In the separate validity study, 30 junior and senior males and females enrolled in an advanced undergraduate psychology course at the University of Missouri participated. Here the students' MARS scores were correlated with how well they performed on the Differential Aptitude Test.

Results from the reliability data indicated that MARS is highly reliable. Furthermore, the test items are "heavily dominated by a single homogeneous factor, presumably mathematics anxiety" (Richardson & Suinn, 1972, p. 553). Strong evidence of validity was determined from the validity test. Results indicated that a high score on MARS is associated with doing poorly on the mathematics test. Richardson and Suinn say, "Since high anxiety interferes with performance, and poor performance produces anxiety, this result provides evidence that the MARS does measure mathematics anxiety" (p. 553). Furthermore, Richardson and Suinn conclude that psychologists can be reasonably sure that a significant reduction in MARS scores after a treatment intervention is not because of retesting with the same instrument or because of intervening events.

An advantage of MARS is that it allows for the assessment of mathematics anxiety for research purposes. Furthermore, mathematics anxious people are readily available for these research purposes. A disadvantage is that MARS is only for adults and is more than likely not suited for children. Furthermore, completing 98 items in one sitting is quite a task for anyone completing MARS. There is no guarantee that the answers to all 98 items are well thought-out and truly honest since a person could become fatigued during the process. Adaptations have been made to MARS in order to assess the mathematics anxiety of adolescents (MARS-A), for elementary school students (MARS-E), and for fourth through eighth grade students (MASC).

MARS-A

The purpose of Suinn and Edward's (1982) study was to develop a revised version of MARS suitable for adolescents. The reason for developing this scale was because attitudes toward mathematics are formed early and career choices (affected by mathematics performance) are made during the last years of high school. The study involved junior and senior high students taking mathematics classes in three public high schools in Arizona and Colorado. The Arizona school housed seventh through twelfth grades; 483 subjects came from this school. The Colorado junior high school provided 1,009 subjects, and the Colorado high school provided 288 subjects.

The Mathematics Anxiety Rating Scale-A and a survey questionnaire served as instruments. MARS-A is a 98-item scale taken from MARS where some words were changed or items replaced for more appropriate questions. All the items described mathematical situations that may appear in life. Each item is rated on a scale of 1 to 5 with 1 being *not at all* to 5 being *very much.* When all the values are added up, the lowest possible score is 98—meaning low anxiety—and the highest possible score is 490—meaning extreme anxiety. The one-page survey questionnaire included questions about grades in coursework, choice of future vocation, and parental occupations.

Subjects also had to list all mathematics and science courses previously taken and enrolled in.

Two methods were used to examine construct validity. First of all, because MARS-A was measuring mathematics anxiety, then high and low MARS-A scores should be associated with different grades in mathematics courses. In order to determine if subjects were high or low anxious on MARS-A, the scores of students in one school (N = 483) were used to determine scores in the 75th (a MARS-A score of 159) and 30th percentile (a MARS-A score of 230). These cut-off scores were used to determine which students were highly anxious and which students had low anxiety in the other two schools (schools A and B). Then the grade averages were compared of students who scored at or below the 30th percentile and at or above the 75th percentile. A two-way analysis of variance was done due to an interest in possible sex differences. For school A (N = 28), results indicated statistically significant main effects for MARS-A scores ($F = 14.08$, $p < .001$) and for sex ($F = 5.98$, $p < .01$). There were no interaction effects. Students with high scores on MARS-A had lower mathematics grade averages than students with low anxiety. For school B (N = 1,009), results indicated statistically significant main effects for MARS-A scores ($F = 40.68$, $p < .001$), but not for sex differences. This confirms the idea that high mathematics anxiety measured by MARS-A is associated with low mathematics course grades. The second method used to examine construct validity factor analysis to determine whether or not a main factor accounted for the variance in all the test items. Eighty-nine items out of the 98 showed factor loadings of > .30 on a single factor. The 89 items made up 91% of the entire MARS-A test. Nine questions showed loadings on a second factor. It was determined by Suinn and Edwards that the first factor be called Numerical Anxiety and the second factor be called Mathematics test Anxiety. In terms of reliability, the Spearman-Brown split-half reliability coefficient was .90 for a sample of 1,313 students. The reliability coefficient using the Guttman Split-half Method was .89. As an index of internal consistency, a coefficient alpha was .96.

Suinn and Edwards note that MARS-A is good for counseling and guidance objectives when it comes to high school juniors and seniors because this is a time when mathematics anxiety can affect students' performance. They claim MARS-A may be useful in identifying students who need help. Furthermore, Suinn and Edwards note that even though two possible factors were identified with the factor analysis, the test anxiety factor does not take away from the entire MARS-A being associated with mathematical grade point average. A disadvantage to MARS-A, like MARS, is the fact that it is comprised of 98 items. Perhaps adolescents completing MARS-A could become fatigued during the process, thus making all 98 answers not necessarily accurate.

MARS-E

Suinn, Taylor, and Edwards (1988) felt there needed to be a suitable measure for determining mathematics anxiety in children since mathematics anxiety and attitudes about mathematics were thought to begin early on. The Suinn Mathematics Anxiety Rating Scale was developed and a study was conducted to test its reliability and validity. The study involved 1119 fourth, fifth, and sixth grade students—51.1% females and 48.95 males. These students were from six different public schools in Fort Collins, Colorado. There were 326 fourth graders, 381 fifth graders, and 412 sixth graders. Most subjects were Caucasian but there were also Hispanics, Asians, Blacks, and American Indian-Alaskan Native.

Instruments used included the MARS-E. This scale has 26 items that are appropriate for upper elementary school children. Each item measures the degree of anxiety the child feels in both in-school and out-of-school mathematical situations. The children responded to each question using a 5-point Likert scale ranging from *not at all nervous* to *very, very nervous*. Another instrument used was the math subtest of the Stanford Achievement Test (SAT), which measured students' abilities with concept of numbers, mathematics application, mathematics computation, and a composite score of these three. The mathematics subtest of the SAT was used in order to see the relationship between mathematics anxiety and mathematics achievement.

Two methods were used to investigate construct validity. First of all, since mathematics anxiety was being measured by MARS-E, then these scores should have significantly correlated with SAT subtest scores and total score. Results indicated that every subject showed a significant correlation at the .001 level between MARS-E and SAT mathematics concepts ($r = -.29$), mathematics applications ($r = -.26$), mathematics computation ($r = -.26$) and total score ($r = -.31$). The second method used to investigate construct validity was "to determine statistically whether a single primary factor accounted for the variance in all test items, presumably with this factor being mathematics anxiety" (Suinn, Taylor, &Edwards, 1988, p. 982). Factor analysis was used to analyze the MARS-E data, and two factors (having an eigenvalue greater than 1.0) were identified. The first factor was identified as Mathematics Test Anxiety, and the second factor was identified as Mathematics Performance Adequacy Anxiety. Cronbach's alpha was used to estimate the reliability of MARS-E, and it was found to be .88.

Compared to the .89 split-half reliability of MARS-A and the test-retest reliability of .78 on MARS, it was determined MARS-E compared favorably.

Overall, MARS-E was found to be a potential instrument as a means of assessing elementary school students' mathematics anxiety. The authors were concerned early on that the 26 items would not be appropriate and meaningful for this age group. However, it turned out that answers to the questions followed a reasonable distribution. The children were able to complete MARS-E in 20 minutes, which indicated the instructions were clear. Also, 26 items is significantly less than the 98 items of MARS and MARS-A, perhaps allowing for more accurate answers from the children since they are less likely to become fatigued. The factor of mathematics test anxiety had been seen before in other studies. The mathematics performance adequacy anxiety factor was unique to this study. However, Suinn et al. (1988) notes that if factors with eigenvalues less than 1.0 had been examined, then a third factor would have existed that was similar to the second factor found in other studies.

MASC

The Mathematics Anxiety Scale for Children was designed for students in the fourth through eighth grades (Chiu & Henry, 1990). According to Chiu and Henry, this instrument provides a consistent way to measure the mathematics anxiety in students in upper elementary and middle school. MASC includes twenty-two items, such as taking a mathematics quiz and being told how to interpret mathematics statements, in which the student is to rate on a scale of one to four. Four represents *very, very nervous*, three represents *very nervous*, two represents *a little bit nervous*, and one represents *not nervous*.

Chiu and Henry conducted a study to test the reliability and validity of MASC. Five hundred sixty-two children participated—270 boys and 292 girls. These children were fourth, fifth. sixth, seventh, and eighth graders from several different school districts in north-central Indiana. A portion of the sample was identified as gifted and a portion was identified as mildly mentally handicapped. Instruments used were MASC (a shortened version of MARS), semester grades, Test Anxiety Scale for Children (TASC), and School Achievement Motivation Rating Scale (SAM). Reliability for MASC was estimated by computing alpha coefficients for all the grade levels and also for the entire group. The alpha coefficients ranged from .90 to .93 with a median of .92. By correlating the MASC scores with the semester grades for fifth, sixth, and eighth graders, evidence of construct validity was determined. The correlations all turned out to be negative and significant. Furthermore, the correlation of MASC and TASC scores turned out to be positive and high. And the correlation of MASC with achievement motivation (measured by SAM) was negative and small but significant. Again, these results provided evidence for construct validity.

An advantage to MASC is that it turns out to be an internally consistent measure of mathematics anxiety for students in grades four through eight. Results determine MASC as an instrument to be used in research in order to evaluate mathematics anxiety. Furthermore, MASC contains only 22 items, which provides for less likelihood of children becoming fatigued while completing the scale. Therefore, responses are more likely to be accurate. A disadvantage to MASC is that there is only some construct validity evidence based on the relationship MASC has with mathematics grades, test anxiety, achievement motivation, and academic ability.

Fennema-Sherman Mathematics Attitudes Scales

The Fennema-Sherman Mathematics Attitudes Scales include nine domain specific, Likert-type scales that measure attitudes toward learning mathematics, according to Fennema and Sherman (1976). The scales can be used as a group of nine, individually, or as a combination of any of the nine. One of the nine scales includes the Attitude toward Success in Mathematics Scale (AS) and measures "the degree to which students anticipate positive or negative consequences as a result of success in mathematics" (Fennema & Sherman, 1976, p. 325). Another scale is the Mathematics as a Male Domain Scale (MD). It measures how much a person views mathematics as a male, neutral, or female domain. The Mother (M)/Father (F) Scale measures the perception students have of their mother's/father's interest and confidence in their ability. Other scales included in this instrument are the Teacher Scale (T), which measures students' perceptions of their teacher's attitudes toward them as mathematics learners, and the Effectance Motivation Scale in Mathematics (E), which measures effectance as applied to mathematics and does not measure a person's interest in or enjoyment of mathematics. The Confidence in Learning Mathematics Scale (C), the Mathematics Anxiety Scale (A) (also referred to as MAS), and the Mathematics Usefulness Scale (U) are also included. Fennema and Sherman claim "it is recognized that the domains of these scales intersect . . . for certain purposes it is important to measure each variable separately" (1976, p. 326).

A common piece of the Fennema-Sherman Mathematics Attitudes Scales discussed in this thesis is the MAS—Mathematics Anxiety Scale. This scale has six positively worded statements and six negatively worded statements. These statements have five responses—*strongly disagree, disagree, undecided, agree,* and *strongly agree.* In terms of reliability, principal factor analyses were used with iterations with normal varimax rotation of the pretest and posttest MAS items. Results indicated that MAS is a highly internally consistent and highly reliable (.88) measure for the population of the study, students in grades 9-12. In terms of reliability, a split-half coefficient was found to be .89.

The Mathematical Self-Concept Scale

Gourgey (1982) developed a scale to measure a person's self-concept about mathematics. The purpose of her study was to develop a valid and reliable means for measuring a person's mathematical self-concept and to explain its relationship to mathematics anxiety as well as mathematics performance. The Mathematical Self-Concept Scale was developed from written statements from undergraduate students enrolled in a basic mathematics course at New York University. There are 32 items—worded positively and negatively--on the scale, which relate to attitude toward mathematical ability. Each positively worded item is rated on a scale of 1 to 5 with 1 being *disagree strongly* and 5 being *agree strongly*. On negatively worded items the scoring is reversed in order for a high score to indicate a favorable mathematical self-concept. One hundred twenty subjects were involved in the study. Twenty-eight undergraduate and graduate students enrolled in a required basic statistics class were part of a pilot study. Ninety-two undergraduate and graduate students enrolled in the same class the next semester comprised the main sample. All students were in the School of education, Health, Nursing and Arts Professions at New York University.

To establish content validity, the scale was given to three mathematicians who were experienced in remediating mathematics anxiety and basic mathematical skills. The mathematicians recommended the modification of a few items, and the scale was given to the pilot sample. As a result, two items that were confusing to the sample were reworded and a few redundant items were taken away, leaving 27 items. Possible scores on the Mathematical Self-Concept Scale ranged from 27 to 135.

The final version of the scale was given to the main sample of students. Other instruments included MARS, an arithmetic skills test, and having to agree or disagree with a list of erroneous mathematics statements. For the pilot sample, the internal consistency reliability coefficient was .98. The reliability of the revised scale was .96.

An interesting discovery from the study was the fact that mathematical self-concept correlated more highly with many variables than did mathematics anxiety. Gourgey claims this suggests that mathematical self-concept may be more powerful and informative as a variable than mathematics anxiety. Gourgey says, " . . . not only does it relate more strongly to other variables involved in learning mathematics, it also supplies more specific information about the nature of the mathematics learner's difficulty" (Gourgey, 1982, p. 9).

The Beliefs About Mathematics Scale

The Beliefs About Mathematics Scale is used in a study by Gourgey (1984). The items and categories on the scale pertain to common mathematics myths, which come from the work of Kogelman and Warren (1979). This scale also contains written statements of New York University students who were taking a basic mathematics course. Four categories are addressed in this scale: mathematics is irrelevant to and separate from other aspects of life; real intelligence is associated with mathematical thinking; mathematics is a male domain; and logic, precision, and mechanical procedure are the most important characteristics of mathematics. There are 25 items on the Beliefs About Mathematics Scale, and obtaining a high score means a person has a high degree of acceptance of these mathematics misconceptions.

In terms of reliability, two pilot samples of statistics students took the scale. Also used for the reliability of this scale were the judgments of three mathematicians who were experienced with remedial mathematics and the treatment of mathematics anxiety.
As a result, two revisions were made. The final version of the Beliefs About Mathematics Scale consisted of 17 items in which responses were based on a five-point Likert scale. A one meant *strongly disagree* while a five meant *strongly agree*.

In terms of validity, a principal components factor analysis was used on the final version. This analysis showed the existence of six factors that accounted for 63% of the variance in the items. These six factors follow: mathematics is precise and mechanical (20%); mathematics is separate from and irrelevant to life (11.4%); mathematics indicates the only real intelligence (9.6%); Mathematics is a male domain (8.2%); mathematics requires a good memory (7.6%); and mathematics requires a special type of logical thinking (6%). These six factors closely correspond to the divisions specified before the final scale was determined. Therefore, the theory on which the scale was based is supported.

Chapter one not only introduces mathematics anxiety and states the research questions, it also describes the causes and preventions of mathematics anxiety according to the experiences of educators and researchers. These causes and preventions prepare the reader in understanding how the studies' subjects may have acquired mathematics anxiety, as well as why certain strategies are tested to see if they do prevent or reduce mathematics anxiety. Chapter one is also beneficial in that it clearly describes the instruments used in the studies, providing a better understanding of a study's process. Overall, chapter one gives the reader the appropriate information for an understanding of chapter two's analysis of research in regards to the research questions.

CHAPTER 2

Literature Review

Chapter two is a review of literature, which focuses on past studies concerning mathematics anxiety. The answers to two questions will be addressed in chapter two. The first question addressed is whether or not relational teaching reduces mathematics anxiety. The discussion to this question is divided into two sections: studies that involve *students* and relational teaching and studies that involve *preservice teachers* and relational teaching. Furthermore, in each of these sections studies are discussed that both support and oppose the idea of relational teaching reducing mathematics anxiety. The reason for separating studies involving students from studies involving preservice teachers is because preservice teachers are often anxious about *teaching* mathematics, whereas students are often anxious about *learning* mathematics. However, both cases, though different in nature, seem to be forms of mathematics anxiety.

The second question addressed in chapter two is how classroom attitudes affect mathematics anxiety. This particular question is not as "cut and dry" as the first question. A variety of studies exist about attitudes and mathematics anxiety in general. This section of chapter two is divided into two sections as well. The first section discusses some studies in which teachers teach mathematics with an emphasis on positive attitudes and how this affects students' levels of mathematics anxiety. The second section discusses the sources and the effects attitudes have on mathematics anxiety. This part of chapter two is divided accordingly because there is a difference between implementing positive attitudes and evaluating attitudes.

Instrumental and Relational Teaching

This section of chapter two discusses studies that support and do not support relational teaching as an effective method for reducing mathematics anxiety. More specifically, the studies are broken up into studies dealing with students and how relational teaching affects their mathematics anxiety and also studies dealing with preservice teachers and how relational teaching affects their mathematics anxiety.

The Effects of Relational Teaching on Students

Gresham, Sloan, and Vinson (1997) conducted a study to determine if a change in instructional strategies would decrease the amount of mathematics anxiety in fourth grade students. The population consisted of 17 fourth grade students in an Alabama elementary school, and the study took place during the 1996-1997 school year. The class contained a non-reader, ADD children, and special education children. The Mathematics Anxiety Scale for Children (MASC) was used to determine the level of mathematics anxiety each child had and was administered in the fall and the spring as a pretest and posttest respectively.

The changed instructional strategies were based on NCTM Standards, which included a more hands-on approach to learning. Manipulatives such as calculators, computer software, geoboards, games, pattern blocks, three-dimensional shapes, and measuring tools were used to teach the students mathematics. There was less of an emphasis on worksheets and lectures. As a result of learning mathematics through a hands-on approach, the researchers anticipated these fourth graders were making connections in mathematics.

Results from the posttest were compared to the results of the pretest. A t-test was used as the statistical test in order to analyze the data. Results indicated that after instructional strategies were changed, the students were more excited about mathematics. With a t statistic of 4.95 and $p < .001$, evidence from the pretest and the posttest indicated a statistically significant decrease in mathematics anxiety from the pretest to the posttest.

Gresham et al. (1997) feel students' use of manipulatives helped them to understand the hows and whys of mathematics. Students thoroughly enjoyed using the calculators and computers and enjoyed implementing those manipulatives into real-life problems like budgeting for a vacation.

Though this study did support the idea that relational teaching reduces mathematics anxiety, some points need to be addressed. For instance, this study was limited in that it included only 17 students. This sample may not be large enough to generalize for larger populations. Furthermore, the time period for this study was only six months. The study was conducted in one school with one classroom teacher, and the researcher served as the implementer as well. Gresham et al. (1997) note that teachers who want to help reduce mathematics anxiety in their students through the NCTM Standards should first become familiar with the Standards. Teachers will need to go beyond the textbook in order to find a variety of activities that both relate to the Standards and support relational understanding.

Norwood (1994) conducted a 14-week study that does not support relational teaching as an effective method of reducing mathematics anxiety. The purpose of Norwood's study was to see if an instructional program for reducing mathematics anxiety would have any effects on the students involved. More specifically, she was interested in the following: when pretest mathematics anxiety scores were used as a covariate, would there be a significant difference in the means of mathematics anxiety posttest scores for students who learned relationally and students who learned instrumentally *and* when pretest mathematics achievement scores were used as a covariate, would there be a significant difference in the means of mathematics achievement posttest scores for students who learned relationally and students who learned instrumentally.

One hundred twenty-three community college students participated in the study. These students were involved in a developmental arithmetic course due to poor performance on a college entrance placement test. The sample was divided into two groups—instrumental and relational. Included in the instrumental groups were 62 students. There were 61 students in the relational groups. For Group I, lesson plans focused on learning and memorizing formulas and rules, as well as mechanical computations. Lesson plans for Group R focused on developing concepts and relating them to fundamental mathematics principles. Group R did not focus on memorizing formulas and rules. Instead, these students focused on *understanding* the mathematics concepts. Group I and Group R spent the same amount of time in class, and treatments took the entire class period. No student was aware of the study being conducted. Six sections of the developmental arithmetic course were involved in the study. The topics covered in the course included whole numbers, fractions, decimals, percent, ratio and proportions, the metric and English systems of measurement, signed numbers, positive and negative exponents, exponential notation, scientific notation, and equations. The researcher and two other instructors each taught two of the six courses. Furthermore, each instructor taught an instrumental section as well as a relational section. The instructors also used the same materials when teaching—the same textbook, lesson plans, hand-outs, quizzes, tests, and finals.

To measure the effectiveness of the course, the Fennema-Sherman Mathematics Anxiety Scale was used as well as the Arithmetic Skills Test of the Descriptive Tests of Mathematics Skills. These instruments were used to look at students' mathematics anxiety rating and student achievement respectively and were given to students the second day of classes and also the thirteenth week of the semester. In both instances, the Fennema-Sherman Mathematics Anxiety Scale was administered before the Arithmetic Skills Test.

The ANCOVA with one covariate--mathematics anxiety pretest scores--was used to test Norwood's (1994) first question. At the .05 level of significance, it may be assumed there exist significant differences between Group I and Group R's mean mathematics anxiety scores. Therefore, in comparison to Group R, the mathematics anxiety scores reduced quite a bit in regards to Group I. The ANCOVA with one covariate—mathematics achievement pretest scores—was used to test Norwood's second question. At the .05 level of significance, it may be assumed there do not exist significant differences between Group I and Group R's mean mathematics achievement scores. Therefore, there was little difference between relational teaching and instrumental teaching in regards to mathematics achievement.

Norwood (1994) concludes that the more structured instrumental approach to teaching tends to reduce mathematics anxiety more so than the less structured relational approach. However, both instrumental and relational teaching can improve the mathematics achievement of remedial college students. Norwood cautions against generalizing these results due to the fact that these conclusions represent a limited population. Norwood discusses how students who are highly anxious are initially more comfortable in a very structured, expository type of learning environment. This might explain why Group I had more of a reduction in mathematics anxiety than Group R. However, she notes that this does not mean instrumental learning is the most appropriate type of learning. Furthermore, Norwood explains this study dealt with an arithmetic course in which memorizing was enough to get by—a deep understanding was not especially necessary in order to be successful. She says, “This could explain why there was no difference in the mathematics achievement posttest scores when Group R and Group I were compared” (p. 252). Also, some students in Group R felt uncomfortable when learning relationally. They often felt frustrated and did not want to know “why” but only the correct answer. Norwood suggests that maybe after these students begin to feel more comfortable learning relationally and begin to succeed in mathematics they will begin to understand the difference in “knowing” and “knowing how.”

Wittman, Marcinkiewicz, and Hamodey-Douglas (1998) conducted a study in which *instrumental* learning reduces mathematics anxiety. Their study deals with CAI—computer assisted instruction. The purpose of the study was to see if a relationship existed between fourth grader’s mathematics anxiety level “before and after automatization of multiplication facts, using CAI drill and practice format” (p. 480). A prediction indicated students with high levels of mathematics anxiety would experience significant reduction in their anxiety as a result of the CAI training. There were two levels of problems on the computer program; when Level I was successfully completed (obtaining a criterion score of 29/30 for two consecutive days) then students could begin

Level II. Level II focused on accuracy and how fast the student could respond to a multiplication fact.

Sixty-three fourth graders in a public elementary school in the Pacific Northwest participated in the study, which took place in the spring term of the school year. There were 33 males and 30 females. Students in remediation programs were not included in the study so that the sample would be more controlled. Instruments used in the study included the Math Builder Program© (Wittman, 1994) and MARS-E, the Mathematics Anxiety Rating Scale—Elementary School Level. As a result of MARS-E (as a pretest), two experimental groups were formed—High Mathematics Anxiety and Low Mathematics Anxiety. These two groups were formed by randomly selecting from the upper ($n = 12$) and lower ($n = 12$) thirds of the mathematics anxiety distribution. Another 12 students were randomly selected from the remaining subjects to serve as the control group. Also, any student in any of these groups who had an overall mathematics aptitude score bigger than 1.0 standard deviation above or below the mean for his or her particular group was dropped from the study and replaced with a student from the pool of remaining students.

The MARS-E pretest and posttest ratings were analyzed using a 2 x 3 x 2 split plot factorial ANOVA. Factors included gender, anxiety condition (High Anxiety, Low Anxiety, Comparison), test session (Pretest, Posttest), and the interactions between the variables. A significant main effect of anxiety condition was revealed ($F(2, 27) = 24.41$, $MSE = 245.08$, $p < .0001$). The same occurred with the three-way interaction between gender, anxiety condition, and test session ($F(2, 27) = 3.64$, $MSE = 210.25$, $p < .039$). The main effect of gender and the other interaction terms were not statistically significant

(F's < 1). Furthermore, Wittman et al. (1998) note the students in the High Anxiety group had significantly higher overall MARS-E ratings than students in the Low Anxiety group (M diff = 34.72, $t(1, 27) = 7.27$, SEM = 4.77, $p < .01$) and also the Comparison group (M diff = 24.43, $t(1, 27) = 5.12$, SEM = 4.77, $p < .01$). The Comparison group's performance was intermediate compared to the High Anxiety and Low Anxiety groups and did not significantly differ from the Low Anxiety group (M diff = 10.29, $t(1, 27) = 2.15$). Overall, results of this study indicated that students who were highly anxious experienced significant reductions in their anxiety as a result of achieving automaticity level performance due to the CAI training. In other words, highly anxious students had significant reductions in their mathematics anxiety due to drill-and-practice—instrumental understanding. Wittman et al. note that students who have difficulty solving mathematics problems due to not knowing basic facts will learn to view mathematics as an anxiety producing experience. If students are provided the opportunity for drill and practice then they can perhaps go beyond the basics. Wittman et al. further note that their study supports the idea that mathematics anxiety is not necessarily a personality trait separate from mathematics performance. They claim, ". . . our position suggests that mathematics anxiety develops as a logical reaction to insufficient learning of fundamental skills" (p. 485). Instructional programs like CAI programs can provide students with mathematics skills in order to become confident in mathematics.

A particularly interesting result of the study is that the females in the High Anxiety group were in the 95^{th} percentile for mathematics anxiety after the pretest and in the 50^{th} percentile after the posttest. The researchers acknowledge that this is encouraging but wonder why only the girls in the High Anxiety group experienced such a dramatic change. The pattern of performance was the same for the boys and the girls in the High Anxiety group up until the mathematics anxiety variable. Wittman et al. (1998) note that they expected the boys to understate their responses on the instruments; however, the boys actually were very truthful. Furthermore, only three boys completed the experiment from the High Anxiety group, which could explain the differential results.

White (1997) also conducted a study in which relational teaching was found not to be an effective method of reducing mathematics anxiety. The study took place over a period of twelve weeks in order to determine if teaching techniques reduce mathematics anxiety. Data for the study came from selected sections of Algebra I in a West Virginia high school. Students involved were in grades 9-12. Forty-eight students comprised the sample—25 of them acted as a control group receiving no treatment. Instead, these students were told how to solve problems from the book, examples were given, and assignments were made. The experimental group received instruction involving games and hands-on activities and often worked outside of the textbook. Students were tested after four or five sections in the book were covered. The same instructor taught all the students for this study. MARS was initially given to all participants in order to determine the level of mathematics anxiety for each. MARS was given again at the end of twelve weeks. Other instruments used in the study included a basic algebra skills pretest and posttest as well as academic grades for major tests and six week grading periods.

Each t-test was set up to test Ho: $A - B = 0$ and H1: $A - B \neq 0$ with $\alpha = .05$. In all the t-tests performed on the data comparing the experimental group with the control group, the null hypothesis was accepted. None of the t-tests were significant ($t < 2$ each time). These results indicated that teaching techniques did not have any significant influence on the level of mathematics anxiety. In reference to MARS as a pretest and posttest, White (1997) claims, “Comparisons using the t-tests indicate that no significant differences were found between the anxiety levels of the two groups at the beginning or end of the treatment period, nor were there any significant differences between each individual group’s beginning and end math anxiety levels” (p. 33). This is indicated by t-tests equaling -1.1866, -1.1467, -0.1981, and -0.2563.

White (1997) notes that in the future more studies need to be conducted about reducing mathematics anxiety. However, White suggests larger samples be used and that studies take place over longer periods of time. She believes teaching techniques rather than teacher attitudes should be the primary focus of future studies. Furthermore, White says more teaching techniques and their effectiveness in reducing mathematics anxiety should be studied.

The Effects of Relational Teaching on Preservice Teachers/Teachers

Vinson, Haynes, Brasher, Sloan, and Gresham (1997) conducted a study with 87 preservice elementary or middle school teachers at Athens State College in Athens, Alabama. These preservice teachers were enrolled in elementary or intermediate level mathematics teaching classes. The purpose of the study was to investigate the changes in the levels of mathematics anxiety in these preservice teachers during two different mathematics materials and methods classes. The changes were a function of using Bruner’s framework –developing conceptual knowledge before procedural knowledge--as well as manipulatives in order to make mathematics more concrete. Vinson et al. (1997) note that the use of manipulatives served two purposes:

> First, the concrete experiences aided in preservice teachers having a better understanding of the mathematical concepts and purposes for procedures. Secondly, using manipulatives assisted the preservice teachers in learning how to teach with more than just modeling a procedure on the chalkboard, for example. (p. 6)

MARS was used as the quantitative instrument. The preservice teachers were given MARS as a pretest to be done at home during the first week of class. During the quarter, a hands-on approach to teaching mathematics was used in the mathematics methods and materials courses. At the end of the quarter—the tenth week—the preservice teachers were asked to complete MARS again at home and bring it back the last day of class. A difference score was found for each preservice teacher by subtracting the pretest MARS score from the posttest MARS score. If the difference score was negative then the subject's anxiety decreased that amount. If the difference score was positive then the subject's anxiety increased that amount over the course of the study.

Informal observations of the preservice teachers in the methods and material classes served as the qualitative instrument in the study. These observations included informal discussions and interviews mostly initiated by the professor.

Results of the study indicate, after comparing group means for the pretest and posttest scores, that overall mathematics anxiety was significantly reduced as a result of relational teaching ($p < .05$). Also, the differences in the pretest-posttest raw scores were highly significant for winter, spring, and summer quarter classes. However, this was not the case for the fall quarter class. A significant F ratio ($p = .0449$) was found by MANOVA across classes for gain, which indicated a significance between fall and winter classes. MANOVA across classes for posttest and pretest raw scores yielded no significant F ratio. Also, during interviews, it was determined that some students felt their mathematics anxiety increased because they had never used manipulatives before and struggled to use them while re-learning mathematics at the same time.

Widmer and Chavez (1982) conducted a study that also dealt with mathematics anxiety and relational understanding. The sample included 230 mathematics teachers from elementary schools in five Kentucky counties. One purpose of the study was to measure the relationship between mathematics anxiety in these teachers and four other teacher characteristics—sex, career goals, type of mathematics training, and recency of mathematics training. One of the research questions was whether or not "fewer teachers who identify their mathematics training as having stressed understanding will show math anxiety than those who identify their mathematics training as having stressed computation" (p. 273).

Widmer and Chavez (1982) developed their own instrument for this population because, at the time, no existing instrument was appropriate for the study. This instrument was an inventory, which included some items that were adapted from the Fennema-Sherman Mathematics Attitudes Scales. The inventory had 36 items with five answer choices for each. Mathematics anxiety was measured by 17 of the items. For the items where agreement indicated anxiety, a 5 meant *strongly agree* and a 1 meant *strongly disagree*. For the items where disagreement indicated anxiety, the reverse scores were used. Teachers involved in the study were classified—as a result of the mathematics anxiety portion of the inventory--as math anxious (raw scores between 57 and 85), non-anxious (raw scores between 17 and 45), or neutral (raw scores between 46 and 56).

A relationship between mathematics anxiety and each of the variables was tested using a Chi-Square statistic ($\alpha = .05$). Results from the study showed that 29 anxious teachers learned mathematics with an emphasis on computation while 8 anxious teachers learned mathematics with an emphasis on understanding. Thirty-one neutral teachers learned mathematics with an emphasis on computation while 9 neutral teachers learned mathematics with an emphasis on understanding. Eighty-seven non-anxious teachers learned mathematics with an emphasis on computation while 55 non-anxious teachers learned mathematics with an emphasis on understanding. Widmer and Chavez (1982) claim "the statistical analysis showed significance at the .05 level, with the difference in the direction hypothesized" (p. 274).

Although Widmer and Chavez (1982) acknowledge that the sample in their study was limited and the self-report nature of the study prevents broad generalizations, they believe their study does possess implications of a psychological nature. Widmer and Chavez claim mathematics needs to be taught for understanding. They feel when this type of teaching occurs, mathematics anxiety will decrease. In order to prevent mathematics anxiety, Widmer and Chavez suggest several relational teaching strategies—manipulatives, games, and relating mathematics to other subjects. Also, Widmer and Chavez note that future research could focus on the relationship between teacher and student anxiety. They do emphasize the idea that all teachers who disliked mathematics or were anxious about mathematics as students do not necessarily dislike teaching mathematics.

Another study by Sloan, Vinson, Haynes, and Gresham (1997) indicated relational teaching as an effective means for reducing mathematics anxiety. The purpose of this study was to look at preservice teachers and determine if levels of mathematics anxiety would decrease as a result of cognitive interventions within a mathematics methods course. These interventions included relational understanding/teaching. Manipulatives, such as pentominoes, tangrams, decimeter squares, and a walk-on number line, were used to learn teaching strategies for K-3 mathematics. The study took place at Athens State College in Athens, Alabama, and the sample included 61 preservice elementary teachers. These preservice teachers were enrolled in a 10-week methods course called Math for the Young Child; this course was taught by the researcher. The study lasted for three 10-week sessions—fall, winter, and spring—and approximately 20 students participated in each of the three sessions.

MARS was used as a pretest and posttest for the 61 participants. Scores were obtained by multiplying the degree of mathematics anxiety from the Likert scale with the number of responses. Pretest scores were also subtracted from posttest scores in order to compare the two tests. Results of the study indicated, with $p < .05$, mathematics anxiety was significantly reduced as a result of relational learning. For group A, the mean mathematics anxiety level reduced by 27.48 points. For groups B and C, levels reduced by 15.90 points and 13.95 points respectively. Also, the t-test comparison of the pretest and posttest raw scores showed a significant reduction in the levels of mathematics anxiety ($t = 4.600603$, $p = .000022$). The fact that Group A had significantly different anxiety reductions could be attributed to several factors, according to the authors. First of all, Group A was taught during the day and students were mostly ages 20-24 whereas Groups B and C were taught at night with non-traditional students coming from other professions. Furthermore, it is noted that the initial anxiety levels were much higher in group A than in Groups B and C. Another factor that may have contributed to the difference was the fact that in Group A there was one person who had a 110-point reduction, which affected the entire group when the score was averaged in.

Personal interviews from the study emphasized that the participants thought their anxiety decreased due to the methodology and atmosphere of the course. Some claimed they finally understood mathematics since they were taught concretely. Sloan et al. (1997) note "the most unanimous and interesting comment was that the participants felt as though their math anxieties could have been prevented in elementary school, if they had received instruction through concrete manipulatives" (p. 22). Other interviews indicated that some of the subjects had an increase in mathematics anxiety because they were unfamiliar with and intimidated by manipulatives. Also, a requirement in the class was to teach a mathematics lesson to a small group which further intimidated these subjects.

Sloan et al. (1997) note that a limitation to their study was that the treatment was short-term. They recommend the following as a result of their study: more research needs to be done on learning styles and mathematics; teaching performance and how it is affected by mathematics anxiety needs to be investigated; and more research needs to be done on personality and mathematics anxiety.

In contrast, a study conducted by Tooke and Lindstrom (1998) does *not* support relational learning as an effective way of reducing mathematics anxiety. The study occurred at the University of Nevada, Reno, and, in the same semester, two sections of Mathematics for Teachers were taught as well as two sections of Mathematics Methods. Sophomores mostly made up the mathematics classes while seniors mostly made up the methods classes. All of these students were preservice elementary teachers. Each of the four classes had approximately 30 students.

The first mathematics section was taught relationally with open-ended questions and manipulatives like base-10 blocks, Cuisenaire rods, and geoboards. The instructor often made connections between what the students were learning and their future careers. The second section of mathematics was taught instrumentally with lecture, homework, and examinations. Relevance of mathematics to students' future careers was also a part of this class.

Both methods classes included the same content as the mathematics classes as well as pedagogy for teaching mathematics. The same instructor who taught the mathematics class instrumentally also taught the two methods courses. Therefore, methods students learned instrumentally but lecture was presented as "this is how this material should be taught" and "this is how students will learn mathematics."

Students in both courses completed MARS-A at the beginning and end of the courses as a pretest and posttest. Results were obtained by finding means and differences of scores on the MARS-A. Pretest results showed that most of the students had similar levels of mathematics anxiety. However, at the end of the semester, students in the mathematics courses experienced no significant difference in the level of mathematics anxiety—no matter if they were taught instrumentally or *relationally* ($p < .05$). Students in the methods courses did have a significant reduction in mathematics anxiety, but these classes were primarily taught instrumentally—not relationally ($p < .05$). Tooke and Lindstrom (1998) note the fact that students whose anxiety decreased as a result of the methods classes may be because students were not told "this is how you do it." Instead, they learned mathematics from the approach of "this is how you need to teach your future students." Tooke and Lindstrom claim that since mathematics anxiety is all about emotions, the emotional deflection of how the mathematics was presented in this study may have made the difference.

Even though no student comments were strongly associated with only the methods course and not with the mathematics course, Tooke and Lindstrom (1998) suggest that the curriculum for elementary teachers should contain a mathematics methods course. It is important for these teachers to understand *how* to teach mathematics; knowing mathematics is not enough in order to be an effective elementary mathematics teacher.

Attitudes

This part of chapter two discusses teachers' attitudes and how they affect students. More specifically, studies about the implementation of positive teacher attitudes and how this affects mathematics anxiety are discussed. Studies about teachers' negative attitudes and how they affect students' attitudes toward mathematics as well as students' mathematics anxiety are discussed in this section, too. Though this section does discuss other factors—parents, mathematics myths, etc.—influencing students' attitudes toward mathematics and their mathematics anxiety, ultimately teachers' attitudes seem to be the primary factor. Thus, teachers' attitudes are the focus throughout this thesis.

In light of the idea that mathematics is difficult, even grueling, for so many people, feelings of dislike, frustration, and failure could have an effect on a person's attitude. Brown (1979) says, "Attitudes together with wants and interests influence and modify the behavior of people" (p. 15). In reference to mathematics anxiety, do attitudes in the classroom—instructors' and students' alike—affect mathematics anxiety? Godbey (1997) states, "It is extremely important to foster positive attitudes about mathematics . . . negative attitudes perpetuate math anxiety" (p. 9). As for mathematics instructors, Lasher (1981) points out that "the instructor must develop a sense of openness and trust" (p. 3). Students often see their teachers as cold and believe their teachers never make mistakes. Lasher claims if teachers were to have a sense of humor and make mistakes in front of the students, then students' views can change. She says, "The developmental mathematics instructor who fosters class discussions and group work can make the students feel secure enough to question and volunteer information without fearing humiliation" (p. 3). Godbey (1997) notes, "Math teachers that show their students a sincere, caring attitude by working to help the student to overcome this terrible impediment to learning will not soon be forgotten by these students" (p. 9).

The Effects of Positive Teacher Attitudes on Students

White's (1997) study (discussed in detail in the section on relational teaching) also deals with teacher attitudes and mathematics anxiety; White wanted to find out if a positive teacher attitude would reduce mathematics anxiety. The experimental group that received modified teaching techniques experienced positive teacher attitudes toward student ability and achievement as well. Again, MARS was used as a pretest and posttest; there were 48 Algebra I students involved in the study. White notes that the teacher attempted to portray a positive attitude about mathematics each day while making the classroom an inviting and comfortable place. Students were not called on unless they volunteered first, and the teacher kept records so as not to call on the same students repeatedly. White says, "Every attempt was made by the teacher to reduce math anxiety and create an enjoyable atmosphere while relating mathematics to everyday world situations" (1997, p. 28).

Results indicated, with a t-test of -0.1981, that no significant changes occurred between the pretest and posttest for the experimental group. This means that positive attitudes did not have an effect on mathematics anxiety. As a result, White (1997) says,

> It is the researcher's opinion that teacher attitudes are difficult to modify and reflect differently to individual groups. In any research of this type, it should be taken into consideration that a teacher automatically tries to reduce math anxiety in all classes and with all groups. It is difficult, if not impossible, for a math teacher to not try to make all students comfortable with math and math concepts. (p. 41)

White also believes that teaching techniques should concentrate on more than just teacher attitudes. Instead, the concentration should be on researching more teaching techniques in order to determine if they have an effect on mathematics anxiety.

Furuto and Lang (1982) conducted a study about attitudes and mathematics anxiety. The purpose of their study was to see if teaching strategies that focused on positive and realistic self-concepts would affect student attitudes and anxiety toward mathematics. Included in these strategies was the idea of helping students develop a positive self-evaluation. Furuto and Lang claim, "It was assumed that self-evaluation was basically the product of how one thinks that the significant other persons in his life perceives [sic] him and relates [sic] to him" (1982, p. 7). The sample for the study included approximately 60 students at Winward Community College who signed up for Mathematics 100: Survey of Mathematics. Topics in this class included sets, logic, algebra, probability, and statistics.

Students were given the Applied Arithmetic and the Elementary Algebra Test as a way to determine ability levels. Also given were MARS and the Mathematics Attitude Scale. Criterion-referenced grading was used on the exams, and the mathematics faculty at Winward Community College created the exams. Data was collected during the fall semester. The control group was taught by a different instructor than the experimental group. There were two sections of Mathematics 100. Both groups were told exactly what to expect from the course if success was to be obtained. Furthermore, for both groups the instructors went over homework, presented new material, showed examples, and gave homework. The difference between the control group and experimental group was in the instructor visits/interviews. For example, the control group was allowed to visit the instructor during office hours, but it was not encouraged. The experimental group was *required* to visit the instructor for fifteen minutes every week. Furuto and Lang (1982) say one of the primary purposes of the weekly meetings was to let the student know that the teacher possessed a positive perception of mathematics and that the teacher genuinely cared about the student. For instance, the instructor showed appreciation for the students, asked students about personal issues, made positive written and oral comments to students, asked if the students had questions about the mathematics learned in class, described mathematics applications relevant to students' interests and goals, and shared personal experiences in order to build students' confidence.

As a result of the pretests—the Applied Arithmetic and Elementary Algebra Test, MARS, and MAS—it was concluded that the control group and experimental group were not significantly different from each other. The t-tests indicated this insignificance with t-tests of 0.4 for the Applied Arithmetic and Elementary Algebra test, 0.31 for MARS, and 0.58 for MAS. However, posttest scores did indicate a significant difference at the .05 confidence level in mean scores for MARS between the experimental group and control group--the t-test was -2.32. The prediction that there would be no difference between the groups was rejected. Also, the experimental group's mean score on the MAS was significantly different at the .10 confidence level from the control group's mean score—the t-test was 1.70. The prediction that there would be no difference in the attitudes of the two groups was also rejected.

Furuto and Lang (1982) claim the positive instructor strategies implemented in the study seemed to have "a significant effect on developing favorable attitudes toward mathematics, on alleviating mathematics anxiety, and increasing mathematics achievement" (p. 17). Furuto and Lang note that for many of the subjects, feelings and emotions about mathematics had probably existed for many years, and through their four-month study many of these feelings and emotions were disappearing. They recommend that future studies be conducted on the future mathematics the students pursue and what type of success these people encounter.

The Effects of Teacher Attitudes

Jackson and Leffingwell (1999) identify instructor attitudes as stumbling blocks in a student's mathematical journey. The main purpose of their research was to see the effects instructor behavior has on mathematics anxiety. The sample for the study included 157 preservice teachers taking a senior-level elementary mathematics class in order to meet the certification requirements for elementary education. The data gathered for this study included written responses to a prompt that said, "Describe your worst or most challenging mathematics classroom experience from kindergarten through college"

(p. 583). The students also had to describe ways that could have made their experiences more positive.

Only 11 students in the study had positive mathematics experiences from kindergarten through college. Of the remaining 146 students, three clusters of grade levels were identified as catalysts for mathematics anxiety: 1) elementary school – especially grades 3 and 4; 2) high school—especially grades 9, 10 and 11; 3) college—especially freshman year. Sixteen percent of the sample remembered a negative mathematics experience in the third or fourth grades. Twenty-six percent remembered a negative experience in grades 9, 10, and 11, and 27% remembered a negative experience during their freshman year in college.

For many of the subjects, no matter when their anxiety began, hostile instructor behavior was identified as a cause of mathematics anxiety. For instance, in elementary and high school, teachers became angry when students asked for help or teachers said, "'How many times do I have to tell you . . . ?'" (p. 584) when pointing out a student's mistakes. Students also noted that teachers seemed to be insensitive and uncaring. For instance, teachers did not respond to students' needs for additional help or clarification or they did not stop students from criticizing their peers. Gender bias was an issue as well. Teachers told girls they did not need mathematics and repeated explanations to boys more often than girls. Furthermore, teachers expected students to understand what was being taught right away and said, "'What's wrong with you? Why didn't you get it the first time?'" (Jackson & Leffingwell, 1999, p. 584). Teachers made students who did not feel comfortable go up to the board to explain problems. The behaviors of the instructors in college differ from the behaviors of the teachers in elementary and high schools. For instance, students were simply told to leave class if they did not understand or they were ridiculed for not having the prerequisite knowledge. If students did not know the material, instructors told them they had no time to waste on them. One instructor did not take into account student needs when he wrote equations with one hand and erased them with the other. Again, girls were told mathematics was not for them. Some instructors were insensitive to students not in the traditional age bracket of 18-22.

Along with identifying specific aspects of instructor behavior in elementary school, high school, and college, Jackson and Leffingwell (1999) also identify the behaviors as either *overt* or *covert*. Overt behaviors are observable behaviors that can be verbal or nonverbal while covert behaviors are implied. An overt behavior would be an instructor refusing to answer student questions while a covert behavior would be an instructor sighing in a demeaning way. Both behaviors can have damaging effects on a person's attitude toward mathematics.

Jackson and Lefffingwell (1999) claim, as a result of the survey, "negative memories were so profound that mathematics anxiety could persist for twenty or more years" (p. 585). They suggest ways instructors can help prevent these circumstances. For instance, instructors need to let students know how enjoyable mathematics is; they need to offer additional help for students who need reinforcement; and instructors need to make mutual respect a rule in their classrooms at all times.

Gourgey (1984) also conducted a study about attitudes and mathematics anxiety. Three research questions were addressed in this study. The first deals with the relationship of mathematics anxiety and acceptance of mathematics misconceptions as well as the relationship of mathematics anxiety and self-concept of mathematical ability.

The second deals with what contributes to the beliefs about mathematics, mathematical self-concept and arithmetic skills to mathematics anxiety and to statistics course performance. The third deals with whether or not beliefs about mathematics and mathematical self-concept discriminate among the following groups: low anxiety, low performance; low anxiety, high performance; high anxiety, low performance; and high anxiety, high performance. Ninety-two undergraduate and graduate students comprised the sample for this study—16 male and 76 female. The students were enrolled in a required basic statistics course at New York University's School of Education, Health, Nursing and Arts Professions. A little more than half of the sample had taken pre-calculus or calculus. Twelve percent had taken only high school algebra or general mathematics. Twenty-six percent had not taken a mathematics course in ten or more years. The median age was 27.

Instruments used in the study included the Beliefs About Mathematics Scale. A high score on this indicated a high degree of acceptance of mathematics misconceptions. The Mathematical Self-Concept Scale (MSC) was also used as an instrument in the study. Other instruments used in the study included the Arithmetic Skills Test, MARS, and a midterm examination that was made up of nine questions at ten points each. Except for the midterm examination, all the instruments were administered at the end of the first class; the midterm examination was administered during the eighth week of class. Materials used in the study were presented in a different order in each class with the exception of the Arithmetic Skills Test. This test was given last for everyone and calculators were prohibited for it. The study does not indicate if calculators were also prohibited throughout the course.

Simple correlation was used to analyze the first research question. Multiple regression was used for the second research question, and a discriminant analysis was used to analyze the third research question. Results indicated that all five instruments moderately intercorrelated. With $r = .32$, mathematics anxiety was positively correlated with acceptance of unfounded beliefs about mathematics. Mathematics anxiety correlated negatively with mathematical self-concept with $r = -.62$. In both cases, $p < .001$. Results of the regression of mathematics anxiety on mathematical beliefs, self-concept, and arithmetic skills indicated that mathematical self-concept was the primary predictor of mathematics anxiety. Also, self-concept, with $F = 38.156$ and $p < .001$, was the only predictor to reach significance. It accounted for 26.2% of the variance while mathematical beliefs and arithmetic skills accounted for 0.6% and 0.2% respectively.

Overall, there existed a relationship between mathematics anxiety and mathematics misconceptions. However, Gourgey (1984) says that it is possible that the relationship is really stronger than the study indicates. This could be due to the idea that once the misconceptions are on paper, the absurdity of them is realized. Outside of the study's environment, however, these misconceptions operate on an emotional level. Furthermore, Gourgey finds it interesting that high anxiety, high performance subjects were closer in self-concept to other high anxiety subjects than they were to other high performance subjects. She says, "It seems that many math-anxious people are not convinced that they have the capability of doing well in math even when they are able to do so; their self-evaluation and anxiety level are not realistic assessments of their ability" (p. 15). Furthermore, Gourgey claims that older students had mathematics difficulties not due to just the passage of time. She says many of them were women, and combined with the passage of time was more than likely the idea that women just were not pushed to excel in mathematics years ago. Between these two circumstances, Gourgey is not surprised at their difficulties. Overall, Gourgey describes a mathematics anxious person based on the results of the study: “This study suggests that the math-anxious individual is one who has a mechanistic, nonconceptual approach to math, a low level of confidence in his or her ability to do math, and a tendency to give up easily . . .” (p. 18).

Brown (1979) concluded from her study that students possessing negative attitudes toward mathematics also possess mathematics anxiety. A purpose of the study was to determine sources of negative attitudes toward mathematics. The sample consisted of seventy-five students at Kennedy King City College in Chicago—45 females and 30 males. These students were enrolled in four mathematics classes taught by Brown—a prerequisite for the nursing program, mathematics for technicians, elementary algebra, and college algebra. The seven instruments used in the study included a three-item true/false questionnaire, MAS, a biodata questionnaire, the College Qualification Tests (CQT), MARS, the California Psychological Inventory (CPI), and a personal interview form. Personal interviews were conducted with students whose scores on the attitude scales indicated negative attitudes toward mathematics. Fifty-one percent of the sample underwent the interview.

In order to determine the impact attitudes had on intellective and nonintellective variables, nonparametric statistical procedures were used. To measure the correlations of attitudes toward mathematics and mathematics achievement, personality characteristics, and mathematics anxiety, the Spearman-rank correlation-coefficient was used. Results indicated, in terms of attitudes and mathematics anxiety, that students with negative attitudes toward mathematics had a high degree of mathematics anxiety ($t = 3.059$, $p < .01$). Furthermore, "conclusions, based on personal interviews, imply that there are very definitely specific factors contributing to the acquisition of negative attitudes toward mathematics in community college students" (Brown, 1979, p. 104). Brown (1979) also notes that the primary variable students pinpointed as affecting their performance was the teacher. Brown says, for immediate action, that "teachers should be made aware of the impact of their actions and the resultant transference of attitudes for which they are directly and indirectly responsible for in their students" (1979, p. 105). Brown suggests in-service training programs for teachers. Furthermore, Brown claims that as a result of her study, there needs to be similar studies done with community college students. Also, she notes that teacher training programs need to prepare preservice teachers to meet the needs of all students.

The purpose of Bohuslov's (1980) study was to evaluate factors that contribute to mathematics anxiety and to establish ways to foster positive attitudes toward mathematics. The study took place at the College of Alameda in California and dealt with three beginning algebra classes. Bohuslov chose these classes because he felt—due to these students experiencing algebra for the first time--these students were high-risk and would have anxieties and attitudes that could affect their mathematics success. One hundred fifty students were involved in the study; these students were women and non-traditional students.

Instruments used in the study came from the Fennema-Sherman Mathematics Attitudes Scales. Five of the nine scales were used and these included the Attitude Toward Success in Mathematics Scale, Attitude Toward Teacher Scale, Mathematics as a

Male Domain, Usefulness of Mathematics Scale, and Mathematics Anxiety Scale. Over a period of five days, these scales were given to the 150 students, with each scale and scoring carefully explained. It was assumed that the students in the sample truly represented typical beginning algebra students and instructors or peers did not influence their responses on the scales. Each scale used in the study contained six positive items and six negative items, the positive items comprising items 1-6. Data was analyzed by calculating the means of each item. A score above three indicated some degree of agreement and a score below three indicated some degree of disagreement. A score below three on the positive items and a score above three on the negative items were considered significant and needed more discussion.

In terms of the Attitude Toward Success in Mathematics Scale, there was a conflict between attitude regarding good grades and trying to hide the results. When discussed, the students claimed peer pressure made them feel that getting good grades was a strange thing. Bohuslov (1980) concluded from the results of the other items that it is clear the students want to do well in mathematics. However, peer pressure seems to be a source of their mathematics anxiety. Furthermore, in terms of attitudes toward teachers, the following statements were considered negative, poor, or conflicting and were worthy of discussion:

> No. 5 "My math teachers have been interested in my progress in math." Women (2.82) Men (3.00)
> No. 6 "I would talk to my math teachers about a career in math." Women (2.25) Men (2.14)
> No. 11 "My math teachers would think I wasn't serious if it [sic] told them I was interested in a career in science and math." Women (3.18) Men (1.93) No. 12 "I have a hard time getting teachers to talk seriously with me about math." Women (3.07) Men (1.86) (Bohuslov, 1980, p. 16-17)

Bohuslov claims it appeared the students' attitudes about their mathematics teachers were uncertain. During discussion, most students said their teachers seemed aloof and distant and did not possess warm personalities. However, Bohuslov concluded that teachers did not seem to impress students in one way or another.

In terms of attitudes with regard to mathematics being a male domain, it turned out that women's attitudes were very strong on positive and negative items. Bohuslov (1980) contributes this to the emerging women's liberation movement going on at the time. Women in the study were inquiring about how mathematics could help them in certain careers. There were some differences in the answers between males and females on the Usefulness of Mathematics Scale. After interviews, Bohuslov concluded that women thought of mathematics as being useful mainly on the job and not very useful in everyday situations. Men felt mathematics is useful on and off the job.

In terms of the Mathematics Anxiety Scale, the following statements turned out to be worthy of discussion but not statistically significant:

> No. 4 "I almost never have gotten shook up during a math test." Women (2.05) Men (2.80)
> No. 5 "I usually have been at ease during a math test." Women (1.31) Men (2.33)
> No. 10 "My mind goes blank, and I am unable to think clearly when working mathematics." Women (3.52) Men (2.48)
> No. 11 "A math test would scare me." Women (4.04) Men (3.84). (Bohuslov, 1980, p. 20)

Bohuslov (1980) determined through discussions that the students were not especially anxious about mathematics but about test anxiety.

Kincaid and Austin-Martin (1981) also conducted a study on attitudes and mathematics anxiety. One of the purposes of the study was to examine the relationship between mathematics anxiety and mathematics attitudes. Three hundred forty-four female college freshmen from a Midwestern women's liberal arts college participated in the study.

Instruments included a 50-item multiple choice test that measured mathematics achievement. Faculty members in the Mathematics Department created the test. Seven of the Fennama-Sherman Mathematics Attitudes Scales were used: the Confidence in Learning Mathematics, Mother Scale, Father Scale, Teacher Scale, Attitude Toward Success in Mathematics, Mathematics as a Male Domain, and Usefulness of Mathematics. Also, a mathematics anxiety scale by Fennama and Sherman was also used. Instruments were administered in a group setting. Students with a score on the Mathematics Anxiety Scale one standard deviation above the mean were considered high math-anxious; those with a score one standard deviation below the mean were considered low math-anxious.

Results indicated students with a high level of mathematics anxiety possess different attitudes toward mathematics than students with no mathematics anxiety. For instance, confidence in ability to learn mathematics was significantly and positively related to mathematics anxiety—for both high and low mathematics anxious students. Mathematics as a male domain was significantly and negatively related to mathematics anxiety for those students who had a high level of anxiety ($r = -0.3838$, $p < .001$). Mathematics as a useful subject seemed to be unrelated to high math-anxious students' mathematics anxiety ($r = -0.1386$, $p < .05$). Attitude toward success in mathematics was significantly and negatively correlated for the high math-anxious students ($r = -0.3930$, $p < .001$). The same correlation was found to be significant and positively correlated for low math-anxious students (r = 0.6201, p < .001). For the high math-anxious students, no relationship existed between achievement and mathematics anxiety (r = 0.0016, p < .05), but a significant and positive relationship existed for the low math-anxious students (r = .07056, p < .001).

Further results found other important relationships. The ANOVA tables for the Mathematics Attitude Scales indicated significant differences between students with high and low levels of mathematics anxiety in terms of confidence in learning mathematics (F = 34.924, df = 1114, p < .001). This indicated that students with low levels of anxiety had greater confidence than high mathematics-anxious students in their ability to learn mathematics. Also, students with low levels of mathematics anxiety perceived mathematics as more useful than their counterparts (F = 25.722, df = 1114, p < .001). In regards to mother's, father's, and teacher's attitudes toward mathematics, it was found low math-anxious students viewed these people's attitudes as more positive than high-anxious students (mother F = 5.432, df = 1114, p < .05; father F = 22.309, df = 1114, p < .001; teacher F = 32.096, df = 1114, p < .001).

Kincaid and Austin-Martin (1981) note that the students who were not mathematics anxious had consistent positive attitudes toward mathematics. These students seemed to be influenced by their parents' and teachers' mathematics attitudes. On the other hand, Kincaid and Austin-Martin claim the high-anxious subjects may possess multiple sources for their anxiety, which are unrelated to and uninfluenced by their mathematics attitudes. Therefore, this group seems to be less consistent and less predictable which makes the correlation of their mathematics anxiety harder to identify. Along with this is the unanticipated finding that the high mathematics-anxious group had negative correlations with mathematics as a male domain, father's perceived attitudes, and attitude toward success in mathematics. Kincaid and Austin-Martin (1981) say, "It is possible that these students' attitudes are being influenced by their adherence to a traditional or nontraditional sex-role definition and by the need to deny the importance of success in a subject area that is anxiety-producing" (p. 7-8). This suggests that there could be a nonrational basis for mathematics anxiety uninfluenced by a person's belief system.

Another surprising finding was the weak relationship between parents' careers and subjects' mathematic anxiety. This was especially true with mothers having a mathematical career and their daughters' mathematics attitudes and anxiety. One explanation Kincaid and Austin-Martin (1981) note is that mathematics anxiety begins at an earlier age than girls are aware of what their mothers' careers entail. Kincaid and Austin-Martin agree further research needs to be conducted on mathematics anxiety and mathematics attitudes in children.

As a result of this study, Kincaid and Austin-Martin (1981) claim mathematics anxiety needs further definition and that a person's preferred sex-role most likely correlates with mathematics anxiety. Also, treatment programs for highly anxious people cannot focus on just mathematics content or just mathematics anxiety reduction because focusing on one may not affect the other.

The discussions seen in chapter two address the research questions presented in chapter one. Chapter two discusses studies that involve students and relational teaching as well as preservice teachers and relational teaching. Some of these studies support relational teaching as an effective means for reducing mathematics anxiety and some do not. Chapter two also discusses studies that involve teachers' positive and negative attitudes and how they affect students' attitudes and mathematics anxiety.

CHAPTER 3

Discussion and Conclusion

The purpose of this review was to determine, through past research, if relational teaching reduces mathematics anxiety and whether teachers' attitudes affect students' attitudes toward mathematics and their mathematics anxiety. A summary of the findings, conclusions, and implications from the research are discussed in chapter three. Furthermore, chapter three is divided into three primary sections. The first section provides a summary and analyzation of the literature review found in chapter two. Limitations of the literature review are discussed in the second section, and recommendations for future studies are given in the third section.

Summary

In this section of chapter three, a summary and analysis of the studies from chapter two are discussed. Published and unpublished studies relating to both relational teaching and mathematics anxiety *and* attitudes and mathematics anxiety are used as the foundation of the literature review. From these studies, the purpose of the review is to assess whether relational teaching is an effective means for reducing mathematics anxiety as well as teachers' attitudes and the effects these attitudes have on students' attitudes toward mathematics and mathematics anxiety.

Evidence from the studies suggests that relational teaching does reduce mathematics anxiety. A discussion of this evidence is broken down according to population in this section. Other studies indicate relational teaching does not reduce mathematics anxiety. A discussion of this evidence is broken down according to population in this section as well. Regarding attitudes, evidence from the studies suggests that the presence of positive teacher attitudes does reduce mathematics anxiety, while other studies find the presence of positive teacher attitudes does not reduce mathematics anxiety. A discussion of both these findings is found in this section. Also, evidence from the studies suggests negative teachers' attitudes do affect students' attitudes toward mathematics as well as their mathematics anxiety. A discussion of this evidence is broken down according to population in this section. The last part of the summary, the conclusion, attempts to answer the research questions found in chapter one based on the literature review.

Research that Found Relational Teaching an Effective Strategy for Reducing Mathematics Anxiety

Elementary Students

One of the eight studies pertaining to relational teaching examined in the literature review supports the idea of relational teaching as a means for reducing mathematics anxiety in elementary students. This study is by Gresham, Sloan, and Vinson (1997). The purpose of their study was to change instructional strategies for 17 fourth grade students and to see if this change decreased students' mathematics anxiety. Though this study supported the idea of relational teaching as a means for reducing mathematics anxiety, limitations to the study include the fact that only 17 students were involved and only one class was involved in the study.

Preservice Teachers

Two of the eight studies dealing with relational teaching support the idea that relational teaching is an effective means for reducing mathematics anxiety in preservice teachers. These two studies are by Vinson, Haynes, Brasher, Sloan, and Gesham (1997) and Sloan, Vinson, Haynes, and Gresham (1997). A larger sample and more varied instruments were used in the study by Vinson et al. (1997) in comparison to the study by Gresham et al (1997). A technique used in this study that was not found in the study by Gresham et al. (1997) was asking the preservice teachers informal questions and having discussions about their responses. A comparison of pretest and posttest means did indicate an overall significant decrease in mathematics anxiety due to relational teaching; however, a few of the preservice teachers' anxiety increased due to an unfamiliarity of manipulatives, as revealed during interviews.

Likewise, a very similar study with similar findings was done by Sloan, Vinson, Haynes, and Gresham (1997). It was determined that hands-on learning significantly reduced the mathematics anxiety many of the preservice teachers had. A noticeable weak point to this study was that Group A had significantly different anxiety reductions than Groups B and C, which could have been due to special circumstances. As discussed in chapter two, Group A had more "traditional" students (aged 20-24) than the other two groups. Also, Group A was taught during the day while Groups B and C were taught at night after working at their jobs. Furthermore, one particular person in Group A had a 110-point reduction in his or her anxiety level. When averaged in with the rest of the levels in Group A, this particular score significantly affected the scores of the entire group. This means that perhaps not everyone in Group A had a reduction in their mathematics anxiety.

Teachers

Widmer and Chavez (1982) provided the only study that dealt with teachers actively teaching. Furthermore, this study was unique because mathematics instruction was not provided for these 230 subjects like many of the other studies discussed in the literature review. A purpose was to measure the relationship between the mathematics anxiety of these teachers and the type of mathematics training they received. Unique to this study was the fact that a Chi-Square statistic was used to analyze the data. Also, Widmer and Chavez developed their own instrument which included some items from the Fennema-Sherman Mathematics Anxiety Scales. Due to the fact that Widmer and Chavez developed their own instrument, the reliability of this study could be questioned in that a statistically reliable scale with validity was not used.

Research that Did Not Find Relational Teaching an Effective Strategy for Reducing Mathematics Anxiety

Elementary Students

One of the eight studies pertaining to relational teaching does not support relational teaching as an effective means for reducing mathematics anxiety in elementary students. This study is by Wittman, Marcinkiewicz, and Hamodey-Douglas (1998). It involved fourth graders who learned and practiced mathematics using a computer program. Whereas in many of the other studies the pretest scores were compared to the posttest scores, this study analyzed the data with a 2 x 3 x 2 split plot factorial ANOVA. Results indicated that highly anxious students experienced a significant reduction in their anxiety due to the instrumental learning via CIA training.

High School Students

One of the eight studies pertaining to relational teaching does not support relational teaching as an effective means for reducing mathematics anxiety in high school students. This study is by White (1997). White's study is similar to Norwood's (1994) (discussed in the next section about community college students) in that there were two groups, and one group received relational teaching while the other group received instrumental teaching. A difference between White's study and Norwood's (1994) study is that White's (1997) study does not support the idea of instrumental teaching as an effective means for reducing mathematics anxiety, whereas Norwood's (1994) does. It should be noted that White's (1997) study speaks volumes in terms of relational teaching. The students involved were taking Algebra I—an abstract subject in which memorization may not suffice. A group of those students were taught algebra with an emphasis on making connections among the concepts in algebra, and their mathematics anxiety still did not decrease. White notes that more studies need to be conducted using larger samples and longer periods of time. An important limitation to White's study is that the best instrument for measuring mathematics anxiety may not have been used. The subjects were high school students and the instrument used was MARS. Perhaps a more suitable instrument would have been MARS-A. By not using the most appropriate instrument, the study's results may not be accurate and reliable.

Community College Students

One study does not support the idea that relational teaching is an effective means for reducing mathematics anxiety in community college students. This study is by Norwood (1994). Conclusions from the study indicate that instrumental teaching, not relational teaching, reduces mathematics anxiety. It should be noted that the students involved in Norwood's study were taking an arithmetic course. Arithmetic is algorithmic in nature; therefore, memorization could suffice for the success in an algorithmic class. Perhaps the fact that subjects decreased their mathematics anxiety as a result of instrumental learning can be contributed to the idea that computation does not call for a deep understanding. Therefore, mathematics anxiety is not as likely to occur. Norwood also points out that very anxious students tend to feel more comfortable in a structured setting in which mathematics is taught instrumentally. She notes that perhaps this is a reason why the instrumental group had a greater reduction in mathematics anxiety.

Preservice Teachers

One study does not support the idea of relational teaching as an effective means for reducing mathematics anxiety in preservice teachers. This study is by Tooke and Lindstrom (1998). This study is especially similar to Norwood (1994) and White's (1997) studies, in that part of the sample received instrumental teaching while the other part received relational teaching. Furthermore, the subjects in Tooke and Lindstrom's (1998) study were taking mathematics for elementary teachers. Like Norwood's (1994) study, some of the mathematics in this course was more than likely algorithmic in nature. Therefore, memorization perhaps was enough for subjects to succeed. As a result, mathematics anxiety decreased. The difference between Tooke and Lindstrom's (1998) study and the other studies is the fact that the instructor made reference to what the preservice teachers were learning and how the knowledge would relate to their future careers. The instructor often presented the mathematics as "this is how you should teach this material" and "this is how your students will learn mathematics." Interestingly, the pretest indicated that most subjects had similar levels of mathematics anxiety. However, the students in the mathematics class who were taught relationally did not have significant differences in their posttest scores from those who were in the mathematics class taught instrumentally. Students in the methods class taught instrumentally *did* experience significant decreases in their mathematics anxiety compared to students who were taught the methods class relationally. Tooke and Lindstrom claim a reason for this could be because the instructor approached the mathematics in a way ("This is how you teach mathematics to your future students.") that perhaps alleviated some of the pressure that often comes with learning mathematics.

The Effects of Teachers' Attitudes

The Effect of Positive Teacher Attitudes on High School Students' and Community College Students' Mathematics Anxiety

Two studies discussed in chapter two dealt with the presence of positive teacher attitudes as a means for reducing mathematics anxiety. The study by White (1997) does not support this idea in terms of high school students. In White's study, the experimental group received positive teacher attitudes as part of its instruction, and results indicated that there were no significant changes in pretest and posttest scores for the experimental group. White claims that her study indicates that teaching techniques may have more of an effect on mathematics anxiety than positive attitudes. Once again, a significant limitation to her study is that perhaps a more appropriate instrument, like MARS-A, should have been used since the subjects were high school students.

One of the two studies where positive teacher attitudes were implemented does support the idea of the implementation of positive teacher attitudes as a means for reducing mathematics anxiety in community college students. This study is by Furuto and Lang (1982). This study seemed to be more reliable than White's (1997) study in that more appropriate instruments were used. Ability levels of the community college students were determined by the Applied Arithmetic and the Elementary Algebra Test, and anxiety levels and attitudes were determined by MARS and MAS. Unlike the results from White's study, it seems positive teacher attitudes do reduce mathematics anxiety, as indicated by posttest MARS scores. The different results in White's study and Furuto and Lang's (1982) study bring up several issues: does the implementation of positive teacher attitudes as a means for reducing mathematics anxiety work better on older students (Furuto and Lang's study involved college students) and does the implementation need to take place outside of the classroom more so than in the classroom (Furuto and Lang's study involved the positive teacher attitudes during office hours)?

Preservice Teachers

Also discussed in the literature review were studies about the effects of teachers' attitudes on students' mathematics anxiety. These studies helped to answer the question of whether or not attitudes in the classroom affect mathematics anxiety. A study by Jackson and Leffingwell (1999) dealt with the sources and effects of attitudes about mathematics anxiety in preservice teachers. Jackson and Leffingwell conducted a study unlike the others in the literature review in that a scale was not used. Instead, a prompt was given in which subjects had to provide a written response. The methods by which Jackson and Leffingwell conducted their study do not seem especially reliable. Though the information is interesting and perhaps useful, the study does not indicate that all 157 subjects were mathematics anxious. Furthermore, the prompt asked the subjects to describe the worst or most challenging mathematics experience from kindergarten through college. Just because a person can describe a bad experience in mathematics does not necessarily mean this person has mathematics anxiety.

College Students

Four studies discussed in chapter two dealt with the sources and effects of attitudes about mathematics anxiety in terms of college students. The study by Gourgey (1984) improved upon the weaknesses found in Jackson and Leffingwell's (1999) study. For instance, Gourgey (1984) used five reliable instruments in the study about attitudes and mathematics anxiety, including the Beliefs About Mathematics Scale, the Mathematical Self-Concept Scale, and MARS. The use of these instruments makes this study more reliable than Jackson and Leffingwell's (1999) because Jackson and Leffingwell used an instrument--a written response to a question—that possessed no reliability and validity. Gourgey (1984) used instruments that had been tested for reliability and validity.

Brown (1979) focused on determining sources of negative attitudes toward mathematics. It was determined that students with negative attitudes toward mathematics also possessed a high degree of mathematics anxiety. From interviews, it was determined that the main source affecting the students' mathematics performance was the teacher. This study was also quite reliable as a result of the seven instruments used to carry out the study, including MAS and MARS. However, a limitation to this study might have been the abundance of instruments. Filling out seven different questionnaires and scales could have proved taxing for some subjects; therefore, the effort involved in responding may not have been 100%.

Bohuslov (1980) conducted a study that looked at ways for students to foster positive attitudes toward mathematics. Overall, it was determined that the students' attitudes toward their teachers were uncertain. While some students claimed their mathematics teachers were aloof and distant, Bohuslov concluded that the students were not affected by their teachers one way or another in terms of attitudes. An unreliable aspect of Bohuslov's study is the fact that it was just assumed all the students involved were high-risk and had anxieties about mathematics since they were in college and taking an algebra course for the first time. While this may have been accurate, no instrument about mathematics anxiety was used on the subjects as a pretest in order to determine the level of anxiety each subject had. A drawback to this study is that attitudes and mathematics anxiety were not dealt with as having a relationship between them; the topics were dealt with separately. Therefore, it seems Bohuslov's study was not overly supportive of the research question.

On the other hand, the study by Kincaid and Austin-Martin (1981) does just the opposite of Bohuslov's (1980) study. The purpose was to examine the *relationship* of attitudes and mathematics anxiety. Unlike Bohuslov, Kincaid and Austin-Martin (1981) did evaluate the subjects' mathematics anxiety levels and grouped them accordingly. Kincaid and Austin-Martin determined that mathematics attitudes differ between students with low mathematics anxiety and students with high mathematics anxiety. The researchers note that students who were not mathematics anxious had consistent positive attitudes toward mathematics.

Conclusion

One focus of this paper is to evaluate whether or not relational teaching reduces mathematics anxiety. Four of the eight studies pertaining to relational teaching support the idea that relational teaching reduces mathematics anxiety. Four of the eight studies do not support this idea. In terms of elementary school students and relational teaching, researchers feel that the reason relational teaching reduced mathematics anxiety is because students were learning mathematics with an emphasis on true understanding. These students liked using hands-on manipulatives to learn, and the setting was small and comfortable. However, elementary school students who experienced a reduction in their mathematics anxiety due to instrumental learning did so, according to researchers, because the topic they were learning was quite algorithmic. As a result, drill-and-practice and memorization were enough to succeed.

In terms of high school students and relational teaching, researchers feel a reduction in mathematics anxiety due to relational teaching did not occur because students were learning an abstract mathematics—one in which memorization is not enough to succeed. These students found it easier to be shown and told how to do algebra instead of having to truly understand it. Overall, it seems the comfort level played a significant part in whether or not high students' mathematics anxiety was reduced by relational teaching.

In terms of college students and relational teaching, it seems that, once again, the level of comfort had much to do with whether or not these students experienced a reduction in mathematics anxiety. For many college students, using manipulatives was a new experience. Having to learn for the very first time how to use manipulatives, along with trying to learn mathematics from the manipulatives, even *increased* some subjects' mathematics anxiety. Overall, the more structured the environment the more comfortable these college students felt and the more likely their anxiety decreased.

In terms of preservice teachers and relational teaching, the researchers feel that if they were taught how to teach their students mathematics and not just how to do mathematics, then mathematics anxiety decreased. Furthermore, some of the preservice teachers involved in the studies did experience a reduction in mathematics anxiety because they enjoyed using manipulatives and developed a deeper understanding in mathematics. However, like other populations, some preservice teachers felt more comfortable learning instrumentally and participating in a more structured environment. Therefore, their mathematics anxiety did not decrease as a result of relational teaching.

Another focus of this paper is to evaluate teachers' attitudes and how they affect students' attitudes toward mathematics and mathematics anxiety. One study in chapter two indicates that positive teacher attitudes reduce mathematics anxiety in community college students. The researchers' reason for this reduction was the idea that the instructor, who met with students individually, cared enough about the students to make a difference in their mathematics confidence and performance. Another study in chapter two indicates that positive teacher attitudes do not reduce mathematics anxiety in high school students. It should be noted that these students received positive teacher attitudes as a whole class, not individually.

Five studies discussed in chapter two indicate that attitudes do affect mathematics anxiety. Researchers pinpoint negative classroom experiences—especially negative teacher comments and attitudes—as a significant source of negative attitudes toward mathematics. Researchers also pinpoint three time periods as to when these experiences occur—elementary school (grades three and four), high school (grades nine, ten, and eleven), and college (freshman year). Another source includes believing mathematics misconceptions, which, in turn, may cause a person to believe that he or she is not good at mathematics. A significant overall effect these attitudes have on students is decreased confidence in mathematical ability—leaving students with very little desire to want to do mathematics and with increased mathematics anxiety.

In terms of populations and attitudes, it seems the experiences and effects are quite similar in elementary school and high school and even in college. Each mathematics anxious person may experience mathematics anxiety at a different time in life, but very similar experiences (mainly negative attitudes) are seen as the catalyst for mathematics anxiety to develop in most people. An uncaring teacher is just as likely to be teaching third grade as he or she is teaching calculus. The belief that mathematics is a male domain is just as likely to be seen in seventh grade as it is in a college senior level mathematics class.

In an attempt to answer the research questions, reliable studies are the focus. Reliability includes the sample size, the sample type, the instruments used, how significant the results were, and the limitations of the study. Out of all the studies examined in chapter two, the most reliable studies were Vinson, Haynes, Brasher, Sloan, and Gresham (1997), Norwood (1994), Wittman, Marcinkiewicz, and Hamodey-Douglas (1998), Tooke and Lindstrom (1998), Furuto and Lang (1982), Gourgey (1984), and Kincaid and Austin-Martin (1981).

I believe that the evidence found in chapter two is accurate. For instance, it is my belief that relational teaching does help reduce mathematics anxiety. However, I also believe that instrumental teaching is effective in reducing mathematics anxiety. Students who are accustomed to learning in a very structured environment probably need to adjust to the unstructured environment relational teaching lends to. Therefore, these students may respond better to instrumental learning—at first. Once these students get used to relational teaching, it is quite possible for their anxiety to decrease. I have seen evidence of students getting accustomed to relational learning in my own classroom. In the beginning of the year I take an informal survey in order to get a feel for how many students are used to learning mathematics through a hands-on approach and how many are not. Throughout the year, it is easy to see which students are comfortable with manipulatives; these students typically have a solid understanding of the material. Others catch on eventually, and with lots of exposure to relational teaching, my classes are used to learning mathematics relationally by the end of the year. Furthermore, I believe that attitudes have a significant relationship with mathematics anxiety. If a teacher is not encouraging in class and a student struggles with mathematics, then it is very possible for mathematics anxiety to develop or increase. If a student has a negative attitude about mathematics, I believe there is a good chance this student is also anxious about mathematics. Studies by Vinson, Haynes, Brasher, Sloan, and Gresham (1997), Norwood (1994), Wittman, Marcinkiewicz, and Hamodey-Douglas (1978), Tooke and Lindstrom (1998), Furuto and Lang (1982), Gourgey (1984), and Kincaid and Austin-Martin (1981) lend evidence in support of these conclusions.

Limitations of the Review

This part of chapter three discusses the limitations of this thesis. Limitations featured in the design of the literature review need to be considered before any general conclusions can be made about relational teaching as an effective means for reducing mathematics anxiety and how teacher attitudes affect mathematics anxiety. One limitation was that the studies in the review dealt with many different age groups. Studies dealt with elementary school students, high school students, and college students.

Preservice teachers were the subjects of some studies, too. One study even dealt with teachers who were actively teaching. The criterion used for selecting the studies were based on the need to find more studies about relational teaching and attitudes instead of finding studies about relational teaching and attitudes of a specific population. Another limitation is the difficulty finding up-to-date studies that dealt with just mathematics anxiety and relational teaching *or* just mathematics anxiety and attitudes. Many of the studies discussed in chapter two also deal with other factors like sex, test anxiety, mathematics achievement, etc. Another limitation is the fact that MARS and MARS-A had 98 items. Because subjects could become fatigued answering 98 questions at one time, responses may not have been completely accurate in some studies, thus causing results of the studies to be inaccurate. It is possible, due to these limitations, that these studies may not be valid in general due to uncontrolled variables and biases.

Recommendations

This part of chapter three discusses the recommendations for future research. In terms of relational teaching and mathematics anxiety, more studies need to be conducted. However, there needs to be separate focuses on elementary school students, middle school students, high school students, and college students, for a study on fourth graders cannot generalize for other grade levels. In addition, these studies need to always have a control group (taught instrumentally) and an experimental group (taught relationally) due to the idea that these two teaching methods represent different goals. For instance, there are times when relational teaching is more appropriate than instrumental teaching and vice versa. One method is not suitable for all mathematics topics; it depends on the overall goal of the students. It is important to know exactly which type of teaching strategy is more effective in reducing mathematics anxiety. Furthermore, in future studies where a group of students is taught relationally, these students should be comfortable with a relational environment first. Otherwise, results may be inaccurate since being uncomfortable with the format of a teaching style could be the cause of mathematics anxiety. Also, studies done in the future need to make a definite distinction between mathematics anxiety and test anxiety. Several studies that focused on mathematics anxiety concluded the subjects had test anxiety instead. While future studies should make an effort to separate these two topics, perhaps more studies should be conducted on how mathematics anxiety and test anxiety are related.

In relation to attitudes, there should be more cut-and-dry studies on simply the relationship between mathematics anxiety and attitudes. More studies need to be done where a group of mathematics anxious students are taught mathematics by a very positive, encouraging teacher. Again, there should be studies done on all the different age groups. It is difficult to say that because elementary students experience a reduction in mathematics anxiety due to positive teacher attitudes then college students will experience the same thing. College students could have possessed mathematics anxiety for years—making it harder to decrease--whereas elementary students could have just started to experience it—perhaps making it easier to decrease. Another important recommendation is to consider the idea that not all negative teacher experiences are due to the teacher hating mathematics or the teacher wanting to intimidate students. Instead, it needs to be remembered that teachers, especially elementary teachers, can have mathematics anxiety themselves. The lack of a positive attitude in the classroom could be directly related to the comfort level that teacher has teaching mathematics.

APPENDICES

APPENDIX A

Plan For Math Success (Arem, 2003, p. 7-8)

My plan for Math Success

1. I list one realistic math success goal I wish to achieve. I state it in specific, positive, measurable terms. I write out, vividly and in detail, exactly what I want. My math goal is:

2. The realistic target date for achieving this goal is:

3. My math goal should meet the following goal-setting criteria (check all that apply):
   ___ I have clearly stated it.
   ___ I value it.
   ___ I believe I can do it.
   ___ I want to do it, and I am motivated.
   ___ I find it rewarding and personally fulfilling.
   ___ I am clear this is what I want, as opposed to other choices.
   ___ It is a realistic possibility for me in terms of my time and ability.
   ___ I envision a plan of action for achieving it.

4. I want to achieve my math goal because of the following benefits and potential satisfactions (list as many as possible; include both tangible and intangible benefits):

5. These are some barriers or obstacles I may face and steps I will take to overcome them:

Barriers	**Steps to Overcome Barriers**

6. These are the positive forces and abilities I can use or strengthen to meet my math goal:

7. These are the people who can help me in achieving my goal:

Name	**Type of Help They Can Give**

8. The significant *action steps* I need to take to meet my math success goals are:

Action Steps	**Target Dates**
a. ___	___
b. ___	___
c. ___	___
d. ___	___
e. ___	___
f. ___	___
g. ___	___

9. Here's how I will reward myself for meeting my math goal:

APPENDIX B

Assessing Your Perceptual Learning Channels (Arem, 2003, p. 78-80)

Carefully read the sentences in each of the following three sections and note if the items apply to you. Give yourself three points if the item usually applies, two points if it sometimes applies, and one point if it rarely applies.

Are You a Visual Learner?

____ 1. I am more likely to remember math if I write it down.'
____ 2. I prefer to study math in a quiet place.
____ 3. It's hard for me to understand math when someone explains it without writing it down.
____ 4. It helps when I can picture working a problem out in my mind.
____ 5. I enjoy writing down as much as I can in math.
____ 6. I need to write down all the solutions and formulas in order to remember them.
____ 7. When taking a math test, I can often see in my mind the page in my notes or in the text where the explanations or answers are located.
____ 8. I get easily distracted or have difficulty understanding in math class when there is talking or noise.
____ 9. Looking at my math teacher when he or she is lecturing helps me stay focused.
____ 10. If I'm asked to do a math problem, I have to see it in my mind's eye to understand what is being asked of me.

Are You a Kinesthetic/Tactile Learner?

____ 1. I learn best in math when I just get in and do something with my hands.
____ 2. I learn and study math better when I can pace the floor, shift positions a lot, or rock.
____ 3. I learn math best when I can manipulate it, touch it, or use hands-on examples.
____ 4. I usually can't verbally explain how I solved a math problem.
____ 5. I can't just be shown how to do a problem; I must do it myself so I can learn.
____ 6. I've always liked using my fingers and anything else I could manipulate to figure out my math.
____ 7. I need to take lots of breaks and move around when I study math.
____ 8. I prefer to use my intuition to solve math problems, to feel or sense what's right.
____ 9. I enjoy figuring out math games and math puzzles when I learn math.
____ 10. I learn math best if I can practice it in real-life experiences.

Are You an Auditory Learner?

____ 1. I learn best from a lecture and worst from the chalkboard or the textbook.
____ 2. I hate taking notes; I prefer just to listen to lectures.
____ 3. I have difficulty following written solutions on the chalkboard, unless the teacher verbally explains all the steps.
____ 4. I can remember more of what is said to me than what I see with my eyes.
____ 5. The more people explain math to me, the faster I learn it.
____ 6. I don't like reading explanations in my math book; I'd rather have someone explain the new material to me.
____ 7. I tire easily when reading math, though my eyes are okay.
____ 8. I wish my math teachers would lecture more and write less on the chalkboard.
____ 9. I repeat the numbers to myself when mentally working out math problems.
____ 10. I can work a math problem out more easily if I talk myself through the problem as I solve it.

____ TOTAL SCORE

My dominant perceptual learning channel is: ______________ (enter the category with the highest total score)

My secondary perceptual learning channel is: ______________ (enter the category with the second highest total score)

My tertiary perceptual learning channel is: _____________ (enter the category with the third highest score)

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