Math Anxiety: What It is and
How It Can Be Prevented by Elementary Classroom Teachers

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Abstract

It is common in our society for people to say, "I am not good at math," or "I hate math," while others feel relaxed and competent in mathematics (Stuart, 2005). An anxiety towards mathematics is common in our students today. Math anxiety includes negative feelings about mathematics, feelings of inadequacy, and general fear and avoidance of mathematics, as defined by Zaslavsky (1994). According to Tobias, people who suffer from math anxiety remember a feeling of sudden death, followed by paranoia and fear that everyone else knows they are 'dumb' in mathematics (1993). Math anxiety is a significant issue faced by many Americans; as Tobias states, low performance and fear of mathematics prevents millions of people from pursuing personal and professional opportunities. There are many possible causes of this anxiety, but its roots can often be traced to unsuccessful or negative experiences with mathematics in school. Elementary mathematics teachers have a unique advantage and responsibility to provide children with positive mathematical experiences to prevent or reduce the presence of math anxiety.

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Chapter 1

Components of Math Anxiety

It is all too common in our society to hear people say, "I hate math," or "I am just no good at math," while others feel relaxed and competent with mathematics (Stuart, 2005). In a written-response survey given to 157 students in a senior-level elementary mathematics class for prospective teachers, Jackson and Leffingwell found that only seven percent of those surveyed had positive experiences with mathematics from kindergarten to college (1999). This indicates that the high numbers of people in this country have negative or neutral feelings towards mathematics or lack confidence in their ability to do mathematics. Whatever the statistics may be, there is a definite problem in the area of mathematics that teachers, especially, need to address. Teachers should be teaching not only the content, but also how to think critically; however, without the skills to think critically about mathematics, many middle level students suffer from what is known as math anxiety (Steele & Arth, 1998).

This paper will define math anxiety, identify possible causes of math anxiety, and list ways for mathematics teachers to prevent or reduce math anxiety in students. The appendix contains a handbook stating the nine most important measures mathematics teachers can take to prevent math anxiety in their students and a table showing the frequency each of the prevention methods was cited in the research literature. The prevention methods with the highest frequencies were chosen for the handbook.

General Anxiety

Anxiety is defined as "an emotion consisting of unpleasant thoughts and sensations as well as physical changes; it is a response to a situation or stimulus perceived to be threatening or dangerous" (Raglin, 2004, p. 139). This emotion, or state of mind, is characterized by three components: (a) cognitive, meaning the apprehension of a negative experience; (b) physiological, including physical symptoms such as increased heart rate, sweating, and dizziness; and (c) behavioral, meaning avoidance or inability to perform (Roy-Byrne, 2001). Some people may use the term 'fear' to describe an anxiety, but according to psychologists such as Roy-Byrne, the distinction is clear; fear is an adaptive and appropriate response to a clear external threat, while anxiety is excessive and inappropriate in relation to the stimulus and frequently extends longer than the aggravating situation.

There are two general types of anxiety: trait and state. Trait anxiety is the higher frequency of an individual to experience anxiety over long periods of time, and state anxiety is the feelings of anxiety at a given moment or situation (Spielberger, 1996). In addition to the general types of anxiety, there are more specific types, which include test anxiety and math anxiety (Hembree, 1990). Since a specific reference to math anxiety was not found in the psychology research literature, the type of anxiety known as math anxiety must be a construct only explored by mathematics educators and researchers. According to Hembree, math anxiety is related to both trait and state anxieties, but results show that math anxiety is specifically related to exposure to mathematics.

Definition of Math Anxiety

When the situation or stimulus causing anxiety happens to be mathematics, the result is a specific form of anxiety known as math anxiety; conditions of situation-dependent anxieties are characterized by the need to escape or avoid the anxietyproducing situation (Hopko et al., 2003). Students who are math-anxious, therefore, tend to avoid mathematics and try to escape situations in which mathematics is required.

Math anxiety includes negative feelings about mathematics, feelings of inadequacy, and a general fear and avoidance of mathematics, as defined by Zaslavsky (1994). These feelings come to interfere with a math-anxious person's ability to successfully work with numbers, and that person will eventually view mathematics as a punishment because it brings such high levels of stress. According to Tobias (1993), people who suffer from math anxiety remember a feeling of sudden death, followed by feelings of fear and paranoia. This fear creates an obsession to not make mistakes and not look incompetent in front of peers. Paranoia soon follows that sudden death feeling; the person believes that everyone else in the class and the teacher know he or she does not understand. Due to the paranoia, they feel they cannot ask questions, or everyone will see how 'dumb they are'. This fear and paranoia can be harmful to students—the fear of exposure—and young adults are especially fearful of exposure (Tobias, 1993). Researchers such as Stuart (2005) and Ma and Xu (2004), indicate that both Zaslavsky's and Tobias's definitions of math anxiety are still accurate today.

Math anxiety is a situation-dependent anxiety that is characterized by avoidance and fear of mathematics. The definitions given by researchers differ slightly , but the overall concept remains the same. In this paper, math anxiety means a fear of and/or negative feelings towards mathematics.

History of Math Anxiety

The research and evidence supporting math anxiety as a unique construct of anxiety are relatively new; the earliest reference made to an anxiety towards mathematics was found in the year 1957 in an article written by Dreger and Aiken, who called it Number Anxiety. They aimed to prove that: (a) Number Anxiety exists separately from general anxiety, (b) Number Anxiety is not related to intelligence, and (c) those with high Number Anxiety tend to get lower scores in mathematics even though intelligence is not significantly lower than other people. Their results supported all three hypotheses to be accurate and true, and they set the stage for further research into this Number Anxiety: "more work is needed to identify just exactly what Number Anxiety is and what differentiates it from other kinds of anxiety" (p. 349). Modern researchers, such as Miller and Bichsel, are still continuing that work decades later.

Miller and Bichsel's more recent study (conducted on adults ranging in ages from 18 to 66) shows that math anxiety is a unique form of anxiety, but it does not exist entirely separate from general forms of anxiety:

> State anxiety, trait anxiety, and math anxiety were all intercorrelated. However, math anxiety was the only type of anxiety that correlated with math performance, relating significantly to both applied and basic math performance. This suggests that math performance contains a component that elicits a specific form of anxiety, one that is not subsumed under either state or trait anxiety (2004, p. 597).

Basic math performance included calculation problems, which ranged from simple addition to geometry, trigonometry, and calculus. Applied math performance questions dealt with skills ranging from basic counting to lengthy word problems. While related to general forms of anxiety, math anxiety proves to be a specialized anxiety related to mathematics.

The results outlined by Miller and Bichsel (2004) indicate math anxiety is the strongest predictor of both basic and applied math performance, followed by verbal and visual working memory. Individuals with high levels of math anxiety scored lower on both the basic and applied subtests. This has substantial implications for teachers, who must recognize students showing early signs of math anxiety, because their mathematical performance will be lowered in the future due to anxiety.

According to Ferguson (1986), there are three dimensions of math anxiety: (a) Mathematics Test Anxiety, which is associated with the anticipation and taking of mathematics tests; (b) Numerical Anxiety, which is associated with the manipulation of numbers; and (c) Abstraction Anxiety, which is associated with the abstract mathematical content introduced specifically in the middle grades. Students who suffer from math anxiety may experience their anxiety in one or more of these dimensions. For example, the anxiety may be limited to mathematical testing situations, or it may include mathematical testing anxiety as well as anxiety with abstract concepts. Extreme cases of math anxiety could encompass all three dimensions. Beginning as a theory of Number Anxiety, math anxiety research has proven it is a unique form of anxiety dealing with mathematics and consisting of three dimensions.

Characteristics

Mathematics is commonly thought of as a discipline based on reason, in which emotion does not play a role. This notion is due to the firmness, fixidity, and precision of mathematics. However, mathematics often brings out strong emotional responses, and those responses are usually negative (Buxton, 1991). It is ironic that the most logical subject brings about the highest emotional response. The presence of math anxiety in our society indicates that what students feel is as important as what they are thinking. For example, often people remember feelings about mathematics in school with intensity but remember little or no content, "I didn't understand the [geometry] concepts and the teacher wasn't very understanding. I remember the teacher yelling at me because I didn't understand" (Perry, 2004, p. 322). That person probably just remembers that the class was unpleasant and does not remember concepts of geometry.

In his study, Buxton (1991) began to see when some students would be successful and when others would experience emotions that stopped their progress in mathematical situations. Two of the situations Buxton describes show how a non-math anxious person faces a mathematical concept or a new problem (first situation) compared with how a potentially high math-anxious person reacts to attempting to understand a mathematical concept (second situation).

The first situation portrays a non-math anxious student facing the challenge of understanding a new mathematical concept or solving a new math problem. As the student receives feedback, and failure or success nears, emotions escalate. These emotions will either improve or lower performance. In general, feedback that hints at failure will hinder performance and leave the student feeling frustrated, while feedback that predicts success will give the student a positive feeling and motivate the student.

The second situation Buxton (1991) investigated consisted of a student attempting a math problem with a considerable amount of previous experience dealing with that type of problem. If, for instance, there are strong emotions attached to that type of problem, then the prior experience—not the present task—will be the main predictor of the outcome. This prior experience, connected with strong emotions, could have been a positive experience, in which high determination and confidence will aid the student. However, more often than not, the outcome is repeated failure, and the student will have difficulty even beginning to solve the problem. Consider the three stages to approaching a problem, according to Krutetskii (cited by Buxton, 1991):

1. Information is received, sorted, and imprinted. This stage is an automatic function of the brain—one does not have to do anything or carry out an action yet.
2. Memory is searched for relevant facts and tools for attacking the problem. Tools are usually more useful than facts; they require judgment on what might be relevant for solving. This stage is still preparation; there is no direct action yet.
3. There is a move from the present knowledge to a new goal. This stage is more active than the first two stages. One must reach a conclusion with the available tools and use intuition to solve the problem.

In this staged theory, both stages one and two are essential. Math-anxious people in this situation, however, become anxious from just hearing or seeing the problem, which brings the inability to receive and accept the information. There may be two different outcomes from the second situation: person A tries to be cooperative, receives help, but still has difficulty. Person B would be not willing to make an attempt, claims he or she cannot remember how to solve the problem, elicits strong emotions, and completely shuts down his or her reasoning process. In the case of person B, feedback is not directed to aid in the process of solving the problem; the case is that Person B has made no attempt at all because of anticipated frustration and failure. Person A reacts 'normally,' or reasonably, while person B reacts in a way in which success is impossible. Continuing to encourage person B to make attempts at solving could be counterproductive and may result in repeated failures. This would reinforce person B's self-defeating image of the inability to do mathematics (Buxton).

Symptoms and Varying Degrees

Symptoms of math anxiety may differ, but Curtain-Phillips (1999) lists how initial panic will usually lead to the inability to continue. First, panic sets in and brings on an intense pressure to find the correct answer. Next, tension builds from the time gone by and a lack of self-confidence leads to uncertainty. Forgetfulness sets in, and the victim doubts his or her own intelligence to solve the problem. Finally, the victim cannot think rationally about the problem anymore, and the pencil stops moving.

The degree to which math anxiety can be experienced ranges from moderate test anxiety, which is math anxiety in its mildest form, to extreme math anxiety, which is associated with physiological symptoms (Perry, 2004). Physiological symptoms will be explained further in a later paragraph. The moderate test anxiety, when it applies to math testing, is what happens when a student understands mathematical concepts in class and while doing homework assignments but panics and is unable to perform on tests. Therefore, the math anxiety these students suffer is restricted to mathematical testing situations.

The most common form of math anxiety, according to Perry (2004) is the moderate math anxiety, which consists of mixed feelings about mathematics: "…I am not thrilled about math and quite frankly it frustrates me…I like math when I get the right answers but when I don't it's another story…the worst is when you do everything right except one little part in the beginning and it messes up the whole problem" (p. 322). High numbers of students in mathematics classes probably feel this way since this is the type of math anxiety that occurs most frequently. These students may not be recognized as having moderate math anxiety because they do feel positive about mathematics at times. Both the teacher and the student should be aware of moderate math anxiety and take steps to minimize or eliminate it; suggestions can be found in Chapter 3.

High math anxiety is the type most easily recognized; the extreme cases of math anxiety bring about physiological reactions such as sweating, nausea, headaches, and dry mouth (Fotoples, 2000). Perry lists many of the same symptoms, in addition to increased heart rate (2004). Once a person reaches a high level of math anxiety, it may be difficult to eliminate that anxiety. Prevention methods should be practiced by teachers, so students will not reach this level. These varied degrees of math anxiety may be present in any mathematics classroom, so both teachers and students need to be aware of the symptoms.

Significance to Teachers

Students with high math anxiety tend to take fewer mathematics classes in high school and show less interest to take mathematics classes in college; they also tend to drop out of math classes without finishing more often than non-math-anxious students (Hembree, 1990). These students show low confidence in their ability to succeed at mathematics, they only take the minimum mathematics classes required, and they are less prepared for a society that increasingly places higher demands on mathematical literacy (Steele & Arth, 1998). Employers today, in an ever-changing technological world, are finding that the level of mathematics ability that had been adequate in the past is no longer sufficient—"Given this increased demand for math skills, a significant number of people are confronting a renewed fear of math: This fear may be imagined or triggered by anxiety-provoking items such as equations, the use of variables, or vocabulary" (Fotoples, 2000, p. 149). Math anxiety can even influence peoples' career choices. Those with high levels of math anxiety may avoid majors dealing with mathematics in college or careers that require number skills; if math-anxious people go into teaching, it is probable that they will dislike teaching mathematics (Ma, 1999).

Sometimes it can be hard for teachers to realize the degree to which students can struggle with understanding mathematical concepts—especially teachers who were very successful at mathematics. In the words of Alexander Solzhenitsyn, "A warm man never knows how a cold man feels" (Tobias, 1993). Adults remember that failing at mathematics felt like sudden death, and the feeling was instant and frightening when they realized that mathematics was not just difficult, it was impossible (Tobias). Additional metaphors Tobias shares that people have used for their sudden realization include a curtain being drawn that they would never see behind or standing at the edge of a cliff, ready to fall. If students are feeling this way towards mathematics, teachers should be concerned about how it will affect their futures.

This chapter has provided a brief overview of the components of math anxiety, including a working definition, history, common characteristics, symptoms, and significance to teachers. The next chapter will focus on the causes of math anxiety.

Chapter 2

Causes of Math Anxiety

Is either a preference or fear towards mathematics inevitable? Do some people start off on the wrong foot or fall behind and never catch up? Are people afraid of mathematics because of some teacher who made them that way? Did some people believe a stereotype that mathematics is only for males or those who have a certain 'math gene'? Many adults, who are anxious about mathematics, blame schools for students leaving feeling like failures (Tobias, 1993), yet, it is impossible to pinpoint one specific cause of math anxiety. The cause(s) for each specific person will differ, and there can be one or many sources. I will now outline some of the possible predictors of math anxiety.

Students who suffer from math anxiety are frustrated and anxious toward mathematics because of poor grades in mathematics, bad math-related experiences, and a lack of understanding of mathematical concepts (Curtain-Phillips, 1999). Therefore, those who are math anxious do not enjoy mathematics and believe that mathematics can only be understood by certain people. These feelings of inadequacy can be so strong, that people with math anxiety will choose careers based solely on their absence of mathematics, says Curtain-Phillips. The causes of this anxiety toward mathematics can be due to parents, teachers, students themselves, societal myths, or any combination of these factors.

Math anxiety may form in students early in their education, and for that reason, it is imperative that all students receive a general education in primary school and hold off specialized training for later in their education (Tobias, 1993). However, it is inevitable that not all students will learn everything. Students, as well as adults, choose to stay within their comfort zone of knowledge. For instance, students who enjoy reading long works of nonfiction or essays might take more history courses, or students who learn best by hands-on activities may take more laboratory courses. According to Tobias, by the time we are adults, we are fairly smart in our specialized fields but feel incompetent when we move outside our comfort zone.

Nature of Mathematics

The nature of mathematics itself is complex and could be a possible reason people feel anxious towards it. Many students get lost in the formulas and terminology used in the language of mathematics:

> Apart from the psychological blocks that may develop over time, some of the issues are these: math is difficult because it is rigorous and complex. As we advance in math, the notation becomes abstract and general. This adds to its mysteriousness. Besides, there are conflicts between the common everyday use of words and the use of these words in math (Tobias, 1993, p. 37).

Teachers should strive to lessen the confusion towards all of the formulas and vocabulary, which causes much anxiety in mathematics students.

The uncertainty in the language of mathematics can contribute to anxiety in students: "for the beginning student, the language of mathematics is full of ambiguity. Though mathematics is supposed to have a precise language…mathematical terms are never wholly free of the connotations we bring to words" (Tobias, 1993, p. 54). Everyday meanings for words and technical mathematical definitions can sometimes differ, which leaves the possibility for misinterpretation. The problem here does not lie with mathematics itself; it is that students are not adequately exposed to the terminology of mathematics (Cornell, 1999). For example, when students first learn multiplication, they learn that the word 'multiply' means to increase, and that their answer will always be larger than the whole numbers they started with: 3 times 6 equals 18. Often students are not warned that multiplying fractions less than one will have the opposite result: one-half times six equals three, which is a value smaller than the six they started with. Students may search through the meanings of the word to try to make sense of 'multiply' in this instance, but simple logic and their own knowledge do not apply. Symbols can cause the same uncertainty; children learn that (-) means to subtract, but later in education they learn that it also can mean 'negative'. As situations such as these continually happen to students, they begin to distrust their own intuition and eventually feel dumb.

As students advance in their mathematical education, mathematics becomes less integrated into the rest of the curriculum than other subjects such as spelling, reading, and writing, unless they are studying science or engineering at the same time as mathematics. Therefore, the mathematics students learn is not immediately applied (Tobias, 1993). This causes mathematics to become more isolated from other areas of study and the students' lives.

Since solving problems is at the heart of mathematics, those who have difficulty doing that will become frustrated. What people do at the beginning of the problem solving process, when they are not sure which formula to use or even if there is a formula to use, is called groping, and it is a difficult thing for the human brain to do (Tobias, 1993). The problem solver is trying to find a solution or an approach in a large number of possibilities. For example, it is easy to find a flashlight in the dark if you are told it is in one of two drawers, but what if you are told that it is in the basement? There are many more places to look, and as the random search continues, you will become more distraught and frustrated. This random searching, or groping, is what beginners in mathematics must often do—especially in word problems (Tobias). It is understandable that beginning mathematics students would find the process upsetting and frustrating. These different facets of the nature of mathematics show its complexity and depth; this is one reason students may be math-anxious.

Teachers

What begins as a set of preferences in school can become a mental confinement, which in time makes us uncomfortable and even anxious to leave (Tobias, 1993). School is difficult enough for students because of their dependency on teachers to lead them. In the words of Tobias, "That is why I believe that a slight discomfort with mathematics acquired in elementary or secondary school can develop into a full-fledged syndrome of anxiety and avoidance by the time one has graduated from school and gone to work" (p.32). Are these preferences inevitable? Most likely they are. But, there is no reason why teachers should encourage these preferences or fuel them with low expectations early in school. Children should be given the opportunity to succeed in all areas.

Another cause of math anxiety lies in the fact that children are extremely literal. When a teacher tells them that they cannot subtract ten from six or divide four by eight, they will assume that it truly is impossible. However, later in their education students will be expected to solve equations like those. Some students may interpret 'least common denominator' to mean the most uncommon number instead of the lowest common number. They may be very embarrassed to have chosen a very high number while the correct answer was a low number. Discussing words that can have different meanings and pointing out exceptions to rules as a class can help remove some of the confusion surrounding mathematics. If students understand that they are not the only ones confused or frustrated, and they identify the reasons for their confusion, they can begin to overcome their doubt before it turns into anxiety.

Most of the time in math class, students learn material and practice the procedures by doing homework from the textbook. Many students do not see any connection to their own lives or the world around them. These thoughts lead them to believe that mathematics is something that cannot be understood and is irrelevant to the world around them. If teachers do not connect the content to their students' lives and give learning a purpose, students are forced to memorize bits of unconnected information (Steele & Arth, 1998; Cornell, 1999). Therefore, mathematics will not make sense if students rely on memorization; if their memory fails them, they will be completely stuck with no tools for solving problems. With an emphasis on rote memorization, students are not introduced to the logical meaning part of mathematics and will also miss seeing the beauty and power of mathematics.

Mathematics is often taught as an exact science with very clear right and wrong answers. There is high pressure placed on students to find the correct answer, and if the methods used do not seem to work, they panic. Questions that emphasize one single correct answer and all other answers as being wrong raise the level of students' emotional response (Burns, 1998). Some modern approaches to teaching mathematics present the study as investigatory mathematics, in which students discover and learn mathematics in ways that are meaningful to them. Whereas writing can be judged good, bad, or acceptable, to naïve students and teachers mathematics has clearly right or wrong answers. Multiple methods of solution are an important part of teaching and learning mathematics, and they will be discussed later in the Prevention section.

One component of math anxiety is a low self-efficacy. Self-efficacy is an individual's belief in his or her capability to accomplish a task (Bandura, 2000). A low self-efficacy has been cited as a reason that people perform poorly on mathematical tasks and avoid taking math classes (Haynes, Mullins, & Stein, 2004), because they perceive themselves as powerless and are not motivated to take action (Flammer, 2001). A student who feels low self-efficacy, therefore, will have increased odds of developing math anxiety. According to literature from the field of psychology, success raises one's positive self-efficacy, while failure lowers it (Bandura, 2000); so the implication for teachers is to provide students with success in mathematics. If these beliefs about their own mathematical skills have an impact on students, then the sources of these beliefs should be investigated.

Teaching methods and attitudes of teachers may be a contributing factor to the development of math anxiety in students. Instructors may be a cause of math anxiety in three different ways. Teachers who are anxious about mathematics themselves may exhibit negative or neutral feelings about mathematics, which their students may then internalize. Students can recognize if a teacher is apprehensive about his or her ability to teach and even understand mathematics, which does not send a positive message to students that mathematical understanding can be achieved. Secondly, instructional methods chosen by teachers may also be a reason some students develop a fear of mathematics. For example, drill and practice methods of teaching mathematics, which do not relate to students' lives, may give students the impression that mathematics is a string of unrelated computations of no importance to their lives (Cornell, 1999). Thirdly, a teacher's attitude toward the subject or toward students may lead to math anxiety; if teachers do not believe in the importance of mathematics in their students' education, it is possible that students will come to feel the same way.

It is unfortunate that some people who suffer from math anxiety will end up teaching mathematics to children at the elementary level. Teachers who are math-anxious themselves can pass this anxiety onto students by portraying a discomfort with mathematics (Furner & Duffy, 2002). In a survey given to college students, Perry found that 85 percent of students who took an introductory mathematics course experienced at least a mild form of math anxiety (2004). Within the college population, pre-service arithmetic teachers are especially prone to math anxiety (Hembree, 1990). With such a high percentage of students feeling anxious towards mathematics, there are bound to be some math-anxious future teachers. These teachers probably will not be teaching mathematics specifically, such as at the middle or high school level, but they will be teaching it as a part of the elementary curriculum—to students who are at a critical point in developing their attitudes towards school and mathematics.

According to Jackson and Leffingwell (1999), there are both covert (implied or veiled) and overt (definite or apparent) behaviors that mathematics teachers exhibit, which may cause math anxiety in students. Covert behaviors would include sighing in a demeaning manner at students, avoiding eye contact, or having an uncaring attitude. Examples of overt behaviors are: not explaining concepts sufficiently, expressing anger in the classroom, refusing to answer questions, showing gender bias, and embarrassing students in front of their peers. Negative verbal remarks would fall under overt behaviors, such as "If you read your textbook, you would not have any problems," or "you should know this" (Jackson and Leffingwell, p.585).

The research conducted by Jackson and Leffingwell (1999) identified three clusters of grade levels at which problems occurred and caused anxiety in students: at the elementary level (especially in grades three and four), at the high school level (especially in grades nine through 11), and at the college level (especially freshman year). Although some students experienced anxiety as early as kindergarten or first grade, 16 percent of those surveyed had their first traumatic event in third or fourth grade. Tankersley (1993) states that fourth grade is the time that a fear of mathematics is often learned, and Jackson and Leffingwell outline four possible reasons for this.

It could be due to the difficulty of material—describing parts of a whole and working with fractions can be stressful, as well as memorizing multiplication facts and formulas. If students are forced to take timed tests, they may develop anxiety through the competition with classmates. Secondly, hostile teacher behavior may also be a cause for math anxiety in elementary students; this would include derogatory comments in front of the class, anger or frustration when asked for extra help, or pointing out mistakes students make in front of the entire class. Thirdly, teachers may exhibit beliefs of a gender bias, in that girls are not as good at mathematics as boys. These instructors did not prevent females from getting belittled by their peers, ridiculed girls more often when asking for clarification, and repeated explanations more often to boys than girls. Lastly, teachers may be perceived as insensitive towards students' needs by: (a) not clarifying for students who need it, (b) not stopping students from criticizing their peers, (c) ignoring chalk allergies by forcing those students to write on the chalkboard, and (d) showing anger and frustration when certain students ask for help (Jackson & Leffingwell, 1999).

Twenty-six percent of the students surveyed reported that behaviors of instructors in grades 9 through 11 had a negative impact on their feelings towards mathematics, while 27 percent contributed their anxiety to instructors during their freshman year of college (Jackson & Leffingwell, 1999). Behaviors shown by these teachers include the following: (a) showing anger towards those who continually ask questions or ask for clarification, (b) having unrealistic expectations for all to understand problems the first time they are explained, (c) embarrassing students in front of their peers by forcing them to get up and demonstrate problems they do not know how to do, (d) portraying a gender bias by helping males more often than females with disregard to ability, and (e) having an uncaring attitude by pretending to be too busy to help students (Jackson & Leffingwell).

Teachers who do not provide a safe environment for students to ask questions openly and make mistakes without the fear of being embarrassed are giving their students reasons to develop a fear of mathematics. Many students do not ask the questions they need to be asking in order to succeed due to a fear of appearing dumb in front of their peers (Tobias, 1993). This fear, which stops them from asking questions, also prevents them from getting the clarification they need to go on, and they become stuck and anxious.

Teachers in the middle grades tend to focus on pencil and paper methods of drill and practice in their classrooms, along with mostly written assessments to measure how much their students have learned, according to Steele and Arth (1998). These methods begin to develop into a cycle, in which students learn a concept, have the problems explained, do the problems, memorize the algorithm, correct the problems, and take a test. This approach to teaching mathematics can be a major source of math anxiety because mathematics appears to students to be unconnected bits of information which do not relate to their own lives (Cornell, 1999; Steele & Arth).

Factors in the classroom environment may also contribute to math anxiety: (a) communication and language barriers, (b) difficulty of material, (c) quality of instruction, and (d) evaluation methods. Competition between students can cause or increase tension felt by certain students. For example, a teacher tells a student to stay at the board until he or she figures out the correct answer, or the teacher tells students to raise their hands when they figure out the correct answer. Students will be terrified of making a mistake in front of their peers up at the board, or they will be afraid of being the last one to raise their hand. This fear of making mistakes leads to low confidence and low feelings of self-worth (Tobias, 1993).

Teachers try to reward accuracy in students by praising correct answers. In the process, however, they end up treating mistakes as failures (Tobias, 1993). Successful and confident mathematics students know that mistakes are valuable in the learning process. Math-anxious students do not realize that making mistakes is okay; therefore, teachers need to be cautious not to praise only the correct answers. Taking an incorrect answer and finding the question it does answer will show students they are not incompetent. Many students want to avoid mistakes at all costs, so many of them never learn how valuable it can be to explore mistakes. It is the responsibility of the teacher to instill that in them.

As students learn mathematics, many develop a dependence on the teacher as well (Tobias, 1993). This is in part due to the fact that students often do not learn how to read mathematical text, and they rely on the teacher to explain the material. Consequently, these students depend on either the teacher or the back of the book to supply them with the correct answer to a problem. Students who are able to develop independence in their ability to do mathematical tasks are those who will less likely form an anxiety of mathematics. Teachers can aid students in becoming more independent in regards to their mathematical skills by encouraging students to trust their intuition and solve problems their own way, as well as teach mathematics as a meaningful topic.

Sometimes a teacher's positive or negative attitude can make all the difference in a student being successful or failing at mathematics. Thus, a positive attitude is essential for teachers to ensure their students do not develop math anxiety. Teachers' attitudes about mathematics begin to influence students beginning as early as kindergarten with simple arithmetic. Research has shown that students generally have positive attitudes towards mathematics and enjoy doing it up until fourth grade (Steele & Arth, 1998). For whatever reason, upper elementary grades are where math anxiety is likely to start, as stated earlier by Tankersley (1993) and Jackson and Leffingwell (1999).

Adults who suffer from math anxiety recall teachers who would not explain the material well enough, teach only to the smart kids, pick on certain students, or often be frustrated with students who did not understand concepts the first time (Perry, 2004). Whether these recollections of mean and incompetent teachers are accurate or not, they show that many people hold teachers' negative attitudes responsible for their own anxiety with mathematics (Cornell, 1999; Hembree, 1990).

Some adults remember mathematics classes having an emphasis on correct answers and timed tests, which created an atmosphere of tension (Tobias, 1993). This tense atmosphere may not have always characterized that classroom; the teacher may have begun the year acting patient with students. At some point, that patience probably turned to frustration from trying to get students to understand 'simple' ideas. Math anxious adults can recall with stunning accuracy the exact wording of a trick question or the day they had to stand alone at the blackboard trying to find the correct answer, even though these events occurred up to 30 years ago (Tobias).

At times, mathematics teachers with the best intentions can unintentionally contribute to math anxiety. A teacher who had a completely happy and successful history of learning mathematics may inadvertently give his or her students the idea that some people—including him or her—are gifted in mathematics, while others just are not (Tobias, 1993). This teacher probably means well, but he or she gives subtle messages that students pick up. A better teacher will be sure to bring the scratch paper used to work out a problem. By doing this, the teacher is demonstrating to students that many false attempts can be made before finding the correct solution. The teacher is also showing students that he or she is not perfect and does not solve every problem with ease.

An important, but overlooked, cause for some students' difficulty in mathematics is the trend in schools today of under-identifying mathematical learning disabilities (Furner & Duffy, 2002). Students who are diagnosed with a learning disability (LD), for example, usually get that diagnosis because of a disability linked to reading or writing. However, a student labeled LD due to a visual processing deficit will have lower reading skills. Teachers sometimes fail to recognize that a visual processing deficit would also affect the student's math skills, according to Fleishner and Manheimer (1997).

Another proposed major cause of math anxiety stems from the theory of multiple intelligences. In many schools, instructors generally teach only to the linguistic intelligent and logical-mathematical intelligent thinkers (Curtain-Phillips, 1999). Students who are not especially strong in these two areas of intelligence often feel lost and powerless in the classroom, as well as confused, frustrated, and defeated, because of the mismatch between the style of learning they experience in the classroom and their own personal learning style (Zaslavsky, 1994). However, each student is unique, and students will inevitably come up with different methods to solve a problem. Individual methods of solving a problem should be encouraged, so students will not come to the conclusion that the way they think and reason is 'wrong'.

Students are very often told in mathematics class that there is one correct answer and one way to get to that answer, and with all the rules and theorems that make up mathematics, that is easy to believe (Fotoples, 2000). In reality, there can be many ways to find an answer; the way in which each student processes information to find an answer depends on his or her style of learning. Some people do follow step-by-step procedures, while others can come up with an answer and work backwards to show their work. The theory of multiple intelligences embraces these different learning styles and strives to acknowledge all students' ways of learning: teachers who recognize their students' various learning methods can plan lessons for musical, bodily-kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, and intrapersonal intelligences (Gardner, 1993). The truth is that everyone learns differently, and instructors who teach to one or two intelligences or use one approach to teaching will limit students' chances for success in mathematics or any other discipline (Fotoples, 2000). There are teacher behaviors, attitudes, and instructional methods that may contribute to math anxiety in students; therefore, if mathematics teachers are aware of these, they will be better able to eliminate or reduce them.

Low Achievement

The presence of math anxiety is positively related to low performance on mathematical tasks (Hembree, 1990; Ma & Xu, 2004; & Furner & Duffy, 2002; Beasley, Long, & Natali, 2001). Of all the negative impacts of math anxiety, the most pressing and commonly discussed questions dealing with what causes this anxiety is whether low performance causes math anxiety or math anxiety causes low performance.

There has been confusion regarding the causal relationship between math anxiety and mathematics achievement. The reason why few researchers have attempted to find the causal relationship lies in the difficulty of methods of research. There is a lack of longitudinal data, so researchers can only rely on cross-sectional data (Ma & Xu, 2004). According to Gollob and Reichardt, however, the problem with cross-sectional data models is that they are misleading due to the inability to take into account time lags properly, and causal factors take time to show effects (1987).

Therefore, there are three alternative models which show the possible causal ordering between the two: (a) high math anxiety causes low mathematical achievement, (b) low mathematical achievement causes high math anxiety, and (c) math anxiety and mathematical achievement are reciprocally related (Ma & Xu, 2004). Researchers supporting (a) begin their research by assuming that math anxiety results in difficulty recalling prior mathematical skills, knowledge, and experiences; Hembree came to the conclusion that math anxiety restricts and lowers performance in mathematics to a serious degree, because increased achievement is a consistent result of reducing math anxiety (1990). With treatment, students who had prior math anxiety can usually raise their level of performance and achieve greater success. According to Hembree, there is no compelling evidence that low performance causes math anxiety; however, one must keep in mind that current research may dispel this notion.

Researchers such as Tobias (1993) and Ma and Xu (2004), who support (b), begin their research with the assumption that math anxiety consists basically of unpleasant memories of poor performance; therefore, they conclude that low mathematical achievement in the past—referring to poor study habits and low test-taking skills—results in high math anxiety. Ma and Xu indicate that, "prior math achievement significantly related to later mathematics anxiety…we concluded that, overall, prior mathematics anxiety hardly related to later mathematics achievement" (p. 175). Though small, the causal priority of mathematical achievement over math anxiety was significant and remained consistent across junior and senior high school grade levels (Ma & Xu).

Supporters of (c) attempt to combine the two competing ideas of (a) and (b), indicating a reciprocal relationship. It is crucial to note that mathematics education may not benefit from any of these findings until researchers are able to discern the actual causal relationship between math anxiety and mathematics achievement (Ma & Xu, 2004). One limitation of mathematical achievement tests is that they may not be pure measures of mathematics achievement since they are given in a test session; it is possible that people with high math anxiety perform poorly on mathematical achievement tests because the anxiety they experience interferes with the actual taking of the test.

Word problems in mathematics cause panic among math-anxious students more than any other aspect of elementary arithmetic, except perhaps fractions (Tobias, 1993). Many teachers do not effectively teach students how to go about solving word problems—students feel as if they must memorize how to do each one, and that would be impossible. While these word problems depress many students because they are not successful with them, it is ultimately a student's attitude that will prevent success, states Tobias.

Students should realize that the solutions to most difficult word problems are not obvious to anyone right away. The action they take when facing the word problem is what will determine whether they will be successful. Constructive action would be to use Polya's four-step process for solving problems (Musser, Burger, & Peterson, 2001, p. 1):

1. Understand the problem
2. Devise a plan
3. Carry out the plan
4. Look back.

A destructive action would include a panicky search for some magic formula or a search for the 'right' formula when a logical approach would work (Tobias, 1993). Low performance on problem-solving, or any other aspect of mathematics, is positively related to math anxiety.

Test Anxiety

There is ample evidence connecting math anxiety with test anxiety; however, test anxiety has not been proven to be directly responsible for the math anxiety that people experience (Hembree, 1990; Haynes, et al., 2004). According to Hembree, both math anxiety and test anxiety are related to general anxiety and affect performance in mathematics and testing in a similar manner. Evaluation methods used in schools today do cause high anxiety in students. A large part of math anxiety may be tied to test anxiety in some students.

Our students have so much pressure placed on them due to excessive standardized testing and the emphasis on paper and pencil evaluations that teachers need to recognize the role that test anxiety plays in student performance (Supon, 2004). Timed tests are also a significant cause of math anxiety in students, and timed tests should be abolished in the classroom (Burns, 1998). Alternative forms of classroom assessment should be considered, since classroom teachers cannot control state and national standardized testing. These alternatives, as well as further suggestions for reducing test anxiety, will be discussed later in the Prevention section. Although not proven as a cause of math anxiety, evidence suggests that test anxiety is related to the anxiety of mathematics.

Parents

Myths surrounding the ability of some to be more successful at mathematics than others may be reinforced by parents; in addition, parental beliefs and actions may cause math anxiety in other ways. According to Zaslavsky (1994), many parents fear mathematics or do not see the importance of mathematics. Other parents project positive attitudes and encourage their children to develop strong mathematical skills. In sum, what is important to the parents will be important to the child, especially in the case of young elementary students who still have very strong relationships with their parents. If a student grows up with parents who think mathematics is unimportant, they will be at a disadvantage in regards to positive support compared to those students who receive parental attitudes that reinforce the idea that mathematics is a subject that is important to future success (Fotoples, 2000). According to Stuart, "…family and peer attitudes may positively or negatively influence students' attitudes towards mathematics, which in turn affects their levels of confidence" (2000, p. 331). Parents need to be made aware of their role in the prevention of math anxiety.

Societal Myths

An excuse commonly made by people who are anxious about mathematics is that they are just not good at mathematics and never will be. By saying this, they are implying that there is such thing as a cognitive ability to do mathematics that some people have and others do not. However, according to Tobias, the problem is not a lack of ability to be successful at mathematics but an anxiety that prevents them from being successful: "you don't have to be a genius to do mathematics. All you need is confidence, persistence, a taste for hard work, and *math mental health*—the willingness to learn the math you need when you need it" (1993, p. 12). Most people have the ability to do mathematics, but they just do not believe they do.

There are myths and stereotypes regarding who can be successful at mathematics and who cannot, and these myths may lead to math anxiety in those who are lead to believe they are true. Myths and stereotypes assume that only some people are able to do mathematics; however, they are outdated and incorrect attitudes which reinforce a fear of mathematics, and they can be supported by teachers, peers, and even family members (Fotoples, 2000). Some students believe that mathematics is not only a subject, but a relationship between a person and the subject—and that mathematics is not only hard, but it is only for those people who are mathematically inclined, or have a 'mathematical mind' (Tobias, 1993). It is the responsibility of teachers, parents, and society to diminish this idea that only some students are gifted with this 'mathematical mind'.

Some people who were left behind or lost at some point in their education are sure that failure was inevitable because it would have been impossible to catch up. This idea that people become anxious about mathematics because they got lost or left behind, and could never catch up also needs to be eliminated (Burns, 1998). In fact, some people internalize the notion that if something has not been learned so far, it is most likely because they cannot learn it at all, and therefore, working hard is worth nothing (Cornell, 1999; Tobias, 1993). Finally these students give up on themselves and the material.

The idea that gender differences are a reality preventing some females from succeeding at mathematics is also falsely believed by some people; however, there is no statistical evidence stating that males are more advantaged than females (Haynes et al., 2004; Ma & Xu, 2004; Perry, 2004). It is imperative that females are not given any reason to believe that they are less able than males to be successful at mathematics—the effects of that belief can be devastating for them. The notion that females are inferior when it comes to doing mathematics is among the many myths that cause them to avoid mathematics (Zaslavsky, 1994).

According to Perry, numerous studies "...have shown that males and females are equal in terms of intrinsic mathematical ability. It is absurd for any individual to think for even an instant that their race or gender makes them mathematically incompetent" (2004, p. 324). Students should be made aware of these myths surrounding mathematical success; with this awareness, perhaps they will understand that negative stereotypes of any kind may cause them to believe they cannot succeed in mathematics. With lowered confidence, their achievement will most likely drop.

Even though higher numbers of females may report math anxiety, the greater frequency does not necessarily mean they have lower performance or higher avoidance of mathematics. Greater numbers of females reporting experiencing math anxiety could be due to females being more willing to admit feeling anxious; therefore, this occurrence would be no less than a reflection of our societal mores (Hembree, 1990). Or, perhaps the greater frequency of females admitting to feeling anxiety towards mathematics is due to females being able to more easily cope with anxiety than males (Hembree).

Although there are no significant differences found in the amount of math anxiety displayed between males and females, different factors have been found to be predictors of math anxiety for each. According to Haynes, Mullins, and Stein, the strongest predictor of math anxiety in females is perceived mathematical ability, or beliefs, followed by teachers' perceived teaching methods and attitudes, while the most significant predictor of anxiety felt by males is actual mathematical achievement and general test anxiety (2004). Teachers should be alert to these different factors which can cause math anxiety in male and female students.

Mathematical performance is related to the amount of math anxiety experienced by the student. While neither males nor females are more likely to feel math anxiety (although females *report* math anxiety more frequently), math anxiety is more predictive of math performance in males than in females (Hembree, 1990; Miller & Bichsel, 2004). This conclusion states only that the performance of males on mathematical tasks is influenced more by their level of math anxiety than it is for females. Females' performance on mathematical tasks depends more heavily on their perceived ability, or self-efficacy, and as already cited, a low self-efficacy is one reason people perform poorly at mathematical tasks and avoid taking mathematics classes (Haynes et al., 2004; Tobias, 1993). According to Merton's theory of the self-fulfilling prophecy, if female students accept the negative stereotypes of a teacher regarding females' inability to do mathematics, then their beliefs will become a reality (Haynes, Mullins, & Stein, 2004). Conversely, a student who has high expectations of her ability to do mathematics will be more likely to succeed. There are myths present in our society that may falsely affect students' perceptions about who can be successful in mathematics.

This chapter has given evidence of several different possible causes for math anxiety in students: the complex nature of mathematics, teachers' attitudes and/or teaching methods, low achievement in mathematics, test anxiety, parents' attitudes and/or actions, and myths present in society. Chapter 3 will address these causes of math anxiety by outlining multiple ways to prevent it.

Chapter 3

Prevention of Math Anxiety

While efforts of reducing math anxiety are being made at the college level and for adults out of school, the real solution to preventing it lies in the elementary schools. Demonstrating the presence of math anxiety in young children, these are the words that came from a fourth grader after completing a state test, "(T)he worst part was dividing fractions. I got so anxious that I thought I would faint" (Black, 2005). It is because of students such as this one that instructors need to recognize their responsibility to provide students with positive mathematical experiences at the elementary level, hence they will not develop this common fear and avoidance of mathematics known as math anxiety.

According to Ma and Xu (2004), early junior high and senior high school years are critical times to set the stage for healthy growth in mathematics achievement and effective prevention of math anxiety. This is also applicable for elementary teachers, given that attitudes towards mathematics are beginning to form in elementary school. In order for teachers to successfully prevent math anxiety, they need to understand and acknowledge the causes. It is "crucial to accurately assess mathematics anxiety at the elementary school level" (Beasley et al., 2001, pp. 23-24).

Equity for All Students

To prevent and/or reduce math anxiety, teachers need to give all students equal chances for success in mathematics—which does not mean giving all students identical instruction but making appropriate accommodations for students who need them. By focusing on what students can do, encouraging multiple solutions, and being sensitive to past failures in mathematics, teachers can prevent math anxiety from forming in their students (Cornell, 1999; Furner & Duffy, 2002). This equality, in terms of opportunities for success, is recognized by the National Council of Teachers of Mathematics (NCTM). According to the NCTM (2000), the students in our country, "...deserve and need the best mathematics education possible, one that enables them to fulfill personal ambitions and career goals in an ever-changing world" (p. 3). In this globally competitive world, people who understand mathematics have much greater opportunities and options in choosing their futures; mathematical competence is highly beneficial to successful futures (NCTM, 2000). Math anxiety is a major obstacle that prevents many students from the gaining access to those great opportunities available.

In order to provide the highest quality instruction for all students, the NCTM has identified six principles important for high quality mathematics education. Equity is the first principle for school mathematics:

> All students, regardless of their personal characteristics, backgrounds, or physical challenges, must have opportunities to study—and support to learn—mathematics. Equity does not mean that every student should receive identical instruction; instead, it demands that reasonable and appropriate accommodations be made as needed to promote access and attainment for all students (2000, p. 11).

If teachers recognize causes of math anxiety, give strong support to all students, and follow the equity principle, students will be less likely to develop math anxiety and less likely to have restricted opportunities in their future endeavors.

Appropriate Pace

While some students grasp mathematical concepts very quickly, others may need more practice and time to understand the same concepts. For that reason, it is impossible to give all students success if the class is moving at the same pace. Many textbooks are designed as preparation for tests, whether teacher-centered, state, or national, and with this format teachers are pressured to teach mathematics quickly; pushing students too fast is harmful to everyone—not just the math-anxious (Fotoples, 2000). Mathematics has a cumulative nature, which requires that a concept be mastered before moving on to the next concept (Cornell, 1999; Fotoples, 2000; Kitchens, 1995; Steele & Arth, 1998). According to Fotoples, if concepts are not understood or if the students do not see connections between the concepts, mathematics will become a series of unconnected ideas, and students' mathematical development will suffer (2000).

Teachers must teach in a way that does not leave behind students who need more time to grasp concepts. Once students like these fall behind, it will be very difficult for them to catch up because they will be lacking the necessary skills needed for future mathematics. Some students suffer from math anxiety because they could not grasp an important part of arithmetic, algebra, or geometry, and for that reason they never could catch up to the teacher again (Tobias, 1993). According to Tobias, some students may not be ready for the transition from concrete to abstract thinking mathematics imposes in elementary school, and that is why they are left behind and form anxiety about mathematics. In the words of Kitchens, "Learning mathematical concepts is like building a house. If the foundation is not good, the outcome will not be a solid structure. A good solid foundation in mathematics includes an understanding of basic concepts" (1995, p. 16).

One way of teaching mathematics, so that all students may work at the pace at which they are able to understand concepts, is to take a mastery approach. In this type of teaching and learning situation, goals are set by the teacher and student, and students study and practice concepts until they are learned. This approach to teaching mathematics for the benefit of every student's individual needs, in which students have numerous opportunities to take similar tests until the concept is mastered, has been a success for Haynes, Mullins, and Stein (2004). Acknowledging the fact that not all students will grasp mathematical concepts in the same amount of time and slowing the pace for those who need it will be beneficial in preventing math anxiety.

Relate to Students' Lives, Other Subjects, and Prior Knowledge

To maximize student comprehension, mathematics teachers need to make connections between the mathematics students are learning in class and their world around them, so they will construct personal knowledge of the information (Furner, Yahya, & Duffy, 2005; Steele & Arth, 1998; Zaslavsky, 1994). According to Zaslavsky,

> The majority of students are not enjoying the 'real math' that would be meaningful to them. In the early grades children are expected to learn mathematical words and symbols, and to master paper-and-pencil procedures…since they see no connection between these procedures and the real world, it all makes little sense to them (1994. p. 135).

Instructors should strive to provide opportunities to learn mathematics in open-ended ways that are interesting and motivating to students, in which they also must think logically and put knowledge together in new ways to solve problems (Steele & Arth, 1998).

In addition to relating mathematics to students' worlds, mathematics instruction should be related to their prior knowledge and other subject areas. Unless new information is associated with knowledge students already possess, it will not have meaning for students (Albrecht, 2006; Brady & Bowd, 2005; Burns, 1998; Furner & Duffy, 2002; Furner et al., 2005; NCTM, 2000; Perry, 2004; Prescott, 2001; Steele & Arth, 1998). Mathematics should not be taught in isolation from other subjects—if students can make connections to science, social studies, writing, and reading, for example, they more likely will remember and apply the new information (Furner & Duffy, 2002; Stuart, 2000). According to Stuart, students can use mathematical skills in science by calculating results for experiments and constructing tables and graphs and also in social studies by drawing maps to scale and calculating differences in dates on timelines, for example (2000). Burns suggests motivating students by connecting mathematics to children's literature; books contain imaginative ideas that can lead to problem-solving situations (1992). By using children's books to create interest, teachers will encourage young children to reason mathematically in their world.

When considering how to design tasks which relate mathematics to students' lives, teachers should recognize the prevalence of technology and use it accordingly. Not only is proficiency with technology increasingly part of our students' lives, but it is also required to compete with others around the world professionally (Cornell, 1999; Burns, 1998; Furner & Duffy, 2002). The use of technology in the classroom, including calculators and computers, leads to opportunities for projects, and it also takes away the anxiety and boredom associated with drill-and-practice worksheets while helping students enjoy mathematics. Teachers should allow students to work with mathematical software and/or mathematical websites on the Internet to build their mathematical skills, as well as technological skills; another possibility is to project websites on a computer and understand more deeply (Cornell, 1999; Curtain-Phillips, 1999; Farrell, 2006; Fotoples, 2000; Furner & Duffy, 2002; Furner et al., 2005; Ma & Xu, 2004; Sloan, Daane, & Giesen, 2002). Teachers should not limit their teaching methods to those preferred by students strong in the linguistic intelligence and logical-mathematical intelligence, or they will run into the danger of not providing an equal chance for all to learn mathematics. In addition to the linguistic and logical-mathematical intelligences, Gardner identifies musical, bodily-kinesthetic, spatial, interpersonal, and intrapersonal intelligences; students may be strong in one or more of Gardner's other five intelligences and benefit from many different activities designed especially for their best way of learning.

According to Zaslavsky (1994), teachers have many factors to consider when planning for instruction which accounts for different learning styles. To prevent teaching only to the linguistic intelligent and logical-mathematical students, teachers should keep in mind students': (a) preferences for working alone or in a group, (b) preferences for a competitive or cooperative environment, (c) preferences for written or oral instruction, (d) strategies for tackling a new problem, (e) speeds at which they work, (f) individual attitudes and need for outside encouragement, (g) aptitudes for taking risks, and (h) impulsive versus reflective styles. For example, teachers can acknowledge students' preferences for working alone or in a group by designing learning tasks in which students work in groups on some tasks and alone on other tasks; the teacher cannot meet the needs of both types of students at the same time but can meet their needs at least part of the time. If these differences are not acknowledged, students will be frustrated with the learning environment as well as themselves.

onto a large screen for the whole class to view (Curtain-Phillips, 1999). Students need to construct their own knowledge of mathematics, and it is vital that teachers make connections to students' lives.

Acknowledge Multiple Learning Styles

Providing multiple learning experiences for students will acknowledge different learning styles. Students who are strong in the visual and spatial intelligence will appreciate bulletin boards, posters, pictures, charts, graphs, diagrams, films, slides, and models portraying mathematical concepts (Curtain-Phillips, 1999). Visual learners will also benefit from information written on the board, written directions, drawings and diagrams, using computer software and Internet, while verbal/auditory learners will understand concepts best when they are explained by a teacher or someone else—they should be encouraged to ask many questions to clarify any confusion (Fotoples, 2000). Students who are strong kinesthetic learners may also profit from activities in mathematics class: manipulatives, role playing, and simulations (Curtain-Phillips). Fotoples also suggests concrete ways of learning, or manipulatives, to aid those kinesthetic learners, such as measuring tools and beads or beans for counting. It is up to teachers to help students find out what works the best for them to learn mathematics successfully.

Since equity for all students is an important goal in the teaching and learning of mathematics, educators need to consider the different learning styles of students when planning for instruction. Students learn in many different ways, as Gardner (1993) outlines in his theory of multiple intelligences, so instructors need to explain concepts in more than one way; this will lead to greater chances that all students will understand—

Since students do learn in different ways, they will also find their answers to problems in many different ways, depending on their style of learning; some will find an answer by following a procedure step-by-step, while other students may know how to identify and solve a problem using a broad sense of knowledge (Burns, 1992; Fotoples, 2000; Ruedy & Nirenberg, 1990; Tobias, 1993). Burns suggests giving students mathematical problems that have several possible ways of solving and encouraging them to share their solutions with classmates. By doing this, students will see and hear different approaches, which reinforces that there is more than one way to solve problems, and they will learn to value their own way of thinking. It is imperative that teachers value each student's method of reasoning, as well as allow flexibility in how students reach solutions and express their solutions. This will lead to increased participation and confidence in students, along with lower levels of stress and anxiety which stem from trying to solve a problem the way the teacher or book wants (Steele & Arth, 1998). By providing multiple learning experiences and accepting more than one way to solve problems, teachers can help prevent math anxiety.

Teach Reading Mathematical Text

Reading a mathematics book is very different from reading a novel or history book, and students need to be taught the way it should be read (Curtain-Phillips, 1999; Kitchens, 1995; Ruedy & Nirenberg, 1990; Tobias, 1993; Zaslavsky, 1994). It is possible to read most texts quickly for understanding, since main ideas and facts are usually stated more than once, and topic sentences are a signal to slow down. Reading mathematical texts differs because things are stated only once, and those concepts must be understood before the reader can move on. Unless they are instructed to read slowly and exactly and are aware that they should reread it to comprehend, they will not benefit from reading.

Teachers should practice reading through concepts slowly with students, model note-taking, and encourage students to work through the examples given in the text. Students may also benefit from writing their own examples of concepts and reading the text aloud with a peer. By teaching students how to read mathematical text, instructors are giving students the skills to become independent learners who do not have to rely on the teacher to gain understanding (Tobias, 1993). Above all, mathematics is a language, and the purpose of mathematics classes is to give students the necessary tools to read and convey mathematical concepts.

Emphasize Concepts and Problem Solving

By emphasizing mathematical concepts and problem solving over simple computations, students will gain a more comprehensive knowledge of mathematics. Even for young children, mathematics is more than just arithmetic and memorization—they should be exposed to all areas of mathematics (Brady & Bowd, 2005; Burns, 1995; Prescott 2001). The National Council of Teachers of Mathematics identifies ten areas of mathematics, or standards, to which students should be exposed: Number and Operations, Algebra, Geometry, Measurement, Data Analysis & Probability, Problem Solving, Reasoning and Proof, Communication, Connections, and Representation (2000). If students can only perform mathematical tasks as outlined in their homework problems without understanding the broad concept, they will not be able to apply the concept to other situations. Closely related to understanding concepts is understanding how to solve mathematical problems. According to Tobias (1993), word problems, or story problems, are at the heart of math anxiety. Therefore, children need to learn strategies for solving word problems, if we do not want them to grow up avoiding mathematics (Burns, 1998; Cornell, 1999; Furner & Duffy, 2002; Ma & Xu, 2004; Stuart, 2000; Tobias, 1993; Zaslavsky, 1994).

Strategies for solving problems should be discussed by teachers and students, and teachers should give students plenty of opportunities to put these strategies into practice. A few strategies include: (a) drawing a picture or diagram to illustrate the problem, (b) turning big numbers into smaller numbers so a method for solving may become apparent, (c) estimating an answer so the final solution may be judged as appropriate compared to an estimated answer, and (d) using logic or common sense (Tobias, 1993).

Additional strategies for problem solving, given by Furner, Yahya, and Duffy, are work backwards, look for a pattern, use trial and error, act it out, and use a table to organize data (2005). Zasklavsky suggests listing the given facts and relationships between them, relating the problem to other mathematical ideas, and checking the solution for reasonability (1994). Ruedy and Nirenberg (1990) highlight six strategies for problem-solving:

1. Breathe.
2. Read questions in small segments, lifting your head and integrating information at each stop.
3. Draw a picture if at all applicable. Use circles and bricks.
4. Rewrite the problem in your own words.
5. Give an off-the-top-of-the-head estimate of the answer.
6. Simplify the problem and do a simplified version first (p. 162).

It would be helpful to students if teachers would visibly display problem-solving strategies in the classroom, such as Polya's four-step process cited in chapter 2. When students and teachers strive for conceptual understanding and examine how problems are solved, rather than just correct answers, students will become less worried about making mistakes and, therefore, better problem-solvers (Steele & Arth, 1998).

Use Manipulatives to Teach Concretely

To aid students in understanding mathematical concepts and solving problems, it is essential for teachers, especially in the elementary school, to use manipulatives. Young students are not cognitively ready to understand abstract ideas without using concrete objects to see relationships; therefore, manipulatives will help all students grasp abstract concepts (Brady & Bowd, 2005; Burns, 1995; Curtain-Phillips, 1999; Furner & Duffy, 2002; Furner et al., 2005; Ma & Xu, 2004; Steele & Arth, 1998; Tobias, 1993; Zaskavsky, 1994). Manipulatives are concrete materials which help students develop conceptual knowledge of mathematical concepts, and using them in the classroom makes pedagogical sense. A young child holding three blocks in one hand and four in the other can 'feel' seven blocks; however, there is no saying that the child will make the same connection when he or she sees the symbols 3 + 4 (Tobias, 1993). Also, students tend to forget things that are only taught abstractly, which can lead to frustration. Manipulatives offer something different from the textbook abstract method of teaching, and when used in small cooperative groups will appeal to students who are strong in the interpersonal intelligence (Curtain-Phillips, 1999).

In a survey conducted by Stuart (2000), three-fourths of students asked said that manipulatives were helpful when learning a new concept. Manipulatives, which can be everyday objects as well as those commercially made, available to use in classrooms may include: money, color counters, rulers, calculators, number cubes, dominoes, playing cards, buttons, tangrams, fraction manipulatives, geoboards, pattern blocks, Cuisenaire rods, miras, unifix cubes, and base ten blocks. Using manipulatives requires more planning and organization on the part of the teacher, but students will most likely take a greater interest in their class work, as well as mathematics in general.

Cooperative Groups and Peer Tutors

To maximize learning and emphasize cooperation over competition, students should be given opportunities to work with cooperative groups or peer tutors (Cornell, 1999; Curtain-Phillips, 1999; Fotoples, 2000; Furner & Duffy, 2002; Furner et al., 2005; Ma & Xu, 2004; Prescott, 2001; Steele & Arth, 1998; Stuart, 2000; Tobias, 1993; Zaslavsky, 1994). In cooperative learning groups, a student may use a term or explanation that the teacher did not think of which may be exactly what another student needed to understand the concept; cooperative learning benefits all students because it is reassuring to know that others have difficulty with mathematics also. For students who are anxious about sharing or asking questions in front of the whole class, small groups will allow them to ask questions more freely, exchange ideas, clarify concepts, and help each other understand ideas in meaningful ways (Curtain-Phillips, 1999). Math anxiety can be caused by the frustration of working alone and getting stuck, so cooperative groups reduce the feeling of isolation.

In a survey by Stuart (2000), some students indicated a dislike towards working in groups due to concerns that one person would do all the work or the group would not get along. Before allowing students to work in cooperative groups, teachers should address together to improve performance and lower anxiety includes and requires students to ask questions for clarification and comprehension.

Patience and a Positive Attitude

A positive attitude and patience will go a long way. "With patience on the part of the student and the instructor, math anxiety can very likely be reduced" (Perry, 2004, p. 324). Instructors must teach with a positive attitude, patience, and enthusiasm while motivating students to be successful and enjoy mathematics (Brady & Bowd, 2005; Fotoples, 2000; Jackson & Leffingwell, 1999; Tobias, 1993). Although the following conclusion from Haynes, Mullins, and Stein is derived from high school teachers' habits, it has implications for elementary teachers: high school teachers tended to produce students with lower levels of math anxiety if they had a positive attitude and showed a willingness to help students (2004).

Teachers should be aware of students' anxiety towards mathematics because any negative comments can break down the little confidence they may have, and these students especially need to feel like they are competent and can learn mathematics with a little hard work on their part (Fotoples, 2000). Teachers are like math coaches—their job is to build students' self-confidence, as well as build and refine the skills needed for success (Stuart, 2000). All mathematics instructors need to understand the impact they have on students: "Students tend to internalize their instructors' interest in, and enthusiasm for, teaching mathematics. Conversely, if students think that the instructor is not happy teaching and does not enjoy being with them in the classroom, they will be less motivated to learn (Jackson & Leffingwell, 1999). Therefore, a positive attitude and patience is vital to prevent students from feeling anxious about mathematics.

these concerns by making their expectations of students' contribution to the group clear in order to prevent those situations from occurring; teachers can also explain that working with people one does not get along with is a part of life and a part of school. Overall, cooperative groups and peer tutors reinforce cooperation over competition and help lower anxiety caused by feelings of isolation.

Encourage Students to Ask Questions

One aspect of preventing math anxiety is the responsibility of the student: asking questions. The student needs to recognize when he or she does not understand a procedure or concept and ask questions immediately to clarify the confusion (Cornell, 1999; Kitchens, 1995; Perry, 2004; Steele & Arth, 1998; Tobias, 1993). Students may think that they are the only ones who have questions on a certain topic, but others often will have the same questions and will be relieved that someone asked. For those students who have too many questions for the instructor to answer during class, it will be necessary to offer one-on-one help outside of class time (Jackson & Leffingwell, 1999).

Students who suffer from math anxiety need a safe classroom climate, in which they feel safe to ask questions—otherwise they will not take the risk to ask a question for fear of being embarrassed. The most important thing that students can do in preventing anxiety in mathematics is to seek help by consulting the textbook, teacher, parent, and so on until they find assistance. This quote demonstrates the value of asking questions: "Students can…help the situation by asking questions instead of getting anxious and aggravated. This also helps out in class discussion and might benefit another student who wanted to ask a question but didn't. It's plain and simple. If everyone works together in the classroom, math anxiety can be lessened immensely" (Perry, 2004, p. 323). Working

Do Not Embarrass Students

Many math-anxious students and adults can recall how they were embarrassed in mathematics class, which can be a significant cause of math anxiety. These words from Alisa demonstrate the lasting impressions of early embarrassment:

> She called on me to stand up and say the twos [multiplication facts]. Well I stood up and started. I said two times one. And I couldn't remember anymore and I stood up there trying to remember and then I was so embarrassed I started to cry. She let me sit down and she told me to stop crying. That's all I remember about third grade (Burns, 1995, p.7).

Therefore, to prevent against math anxiety, teachers should make a conscious effort not to embarrass or single students out in class (Cornell, 1999; Curtain-Phillips, 1999; Jackson & Leffingwell, 1999; Perry, 2004; Tobias, 1993).

Choose students to work at the board with caution—some students will see it as punishment or torture and will panic (Steele & Arth, 1998). Students also must realize that the reason they are asked to work at the black/whiteboard is so that everybody in the class can see their procedure and benefit from it. For students who are anxious about going up to work on the board, teachers can allow them to go up in pairs or groups until they feel comfortable. Comments made from a teacher may also embarrass students, even though that was not what the teacher intended; replace comments such as, "this is a better way to do it," with "that method works, and here is another way to do it" (Steele & Arth, 1998, p. 45). Teachers' actions have profound effects on students' confidence and attitudes toward mathematics, so embarrassing them in class is harmful.

Make Mathematics Experiences Successes

To prevent math anxiety, instructors can make sure students do not feel like failures by making sure that students' first experiences with mathematics in school are successful. With greater success in mathematical performance, math anxiety will decrease (Furner & Duffy, 2002; Hembree, 1990). According to Tobias, most people leave school feeling like failures (1993, p. 33). Therefore, it is imperative that students feel successful in their early mathematics education, and they believe that they can be successful in mathematics. According to Ma and Xu (2004, p. 176), who found low mathematical achievement in early grades is related to higher levels of math anxiety:

> One of the most effective ways to reduce mathematics anxiety of boys is to improve their mathematics achievement (because, for boys, decline in mathematics achievement intensifies mathematics anxiety), whereas for girls, one of the most effective ways to reduce mathematics anxiety is to prevent it from taking shape (because, for girls, mathematics anxiety has the tendency to last in a stable manner over time once it takes shape).

It is a common occurrence that a student's best subject is the one that he or she enjoys the most and has the most success; Stuart (2000, p. 334) states that "people like to do something if they are good at it, and to feel good about mathematics, you have to believe that you are good at it. Therefore, as teachers, we must be successful mathematics coaches—the ones to build self confidence while refining the skills to be successful."

Although there are both supporters and critics, it is a widely accepted view that teachers should give problems to students in which they will rarely fail and try to make certain students experience high rates of success (Buxton, 1991). However, many teachers are aware that students usually enjoy repetitive work at which they are competent and successful—for example rows and columns of multiplication exercises—and may give repetitive work too often. In this type of situation, students feel mild satisfaction from the continued success of simply recalling answers; however there is no development of new knowledge. Therefore, the teacher and school are not fulfilling their fundamental goal—which is to have students learn. Repetitive work, such as drill and practice exercises, increase proficiency of computational skills and should be only one portion of the mathematics curriculum. Teachers should also strive to teach new material and concepts successfully.

There is a time and place for drill and practice, as described previously, but goals should not be too easily achieved. If students have only easy successes in mathematics, later they will be easily disheartened by failure (Bandura, 2000). Levels of satisfaction depend upon the difficulty of the problem. Students who attack and successfully solve a difficult mathematical problem will feel very competent and successful. Even a lengthy attempt at a difficult problem can bring satisfaction to someone who is not drastically frustrated with mathematics and doubts his or her own competence. Failure at all levels needs to be handled with caution, and an effective teacher knows this. The largest obstacle in teaching mathematics appropriately to students is knowing how and when to adjust the level of difficulty for a particular student at the right time (Buxton, 1991).

Talk About Frustrations and Anxiety

Talking with students about mathematics and the anxiety that people can feel when confronted with mathematical situations can help ease and prevent math anxiety. Students should understand how they developed a fear or avoidance of mathematics, and this can be realized through talking about mathematics (Furner & Duffy, 1992; Jackson & Leffingwell, 1999; Steele & Arth, 1998; Tobias, 1993). It is the unfortunate reality that people who do not like mathematics do not like to talk about it. Nevertheless, this avoidance does not solve the issue; mathematics does not go away. People use mathematics every day to handle money, tell time, find percentages, determine a tip, and decide which cell phone plan is the best bargain (which requires mathematical analysis). According to Tobias, talking about mathematical concepts and processes, as well as feelings of frustration and failure is the central process for treatment. It is essential for people with math anxiety to understand that they are not the only ones suffering from this specialized form of anxiety.

For students who are anxious about mathematics, using children's literature can be a successful way to stimulate discussion and ease their anxiety. Bibliotherapy is the term given to this method of treatment. It sounds clinical, but it is simply the method of relating literature to what math-anxious students are feeling (Furner & Duffy, 1992). The characters in the stories chosen must experience a trauma similar to what the students are going through. A discussion of the literature leads to a discussion about feelings of anxiety, and students can begin to get to the bottom of their fear. *Math Curse,* written by John Scieska (1995), is picture book about a child with math anxiety. Reading this book aloud to a class can generate a discussion about math anxiety and the students' feelings in comparison to the character in the book. This discussion about the anxiety some people feel when doing mathematics will help ease some students' anxiety.

Write in Mathematics Class

To some, mathematics and writing may seem like oil and water—that is, mathematics is all numbers and has nothing in common with writing; however, writing about mathematics can help students find out what they know and what they do not know, as well as help them think more deeply about their own learning (Burns, 1995). Writing in mathematics class can take many forms, such as journals and double-entry notebooks to written solutions to problems, but whatever the format, students will benefit from transmitting their thoughts and feelings to paper (Curtain-Phillips, 1999; Prescott, 2001; Ruedy & Nirenberg, 1990; Steele & Arth, 1998; Stuart, 2000; Zaslavsky, 1994). For elementary students in the primary grades, who cannot write about mathematics, encouraging them to think out loud while working on mathematics is an effective way for them and others to catch mistakes (Furner et al., 2005). Students with lower writing abilities could accomplish this task by keeping an audio journal, in which they recorded their thoughts and feelings into a tape recorder (Furner & Duffy, 2002).

Writing in a double-entry notebook can ease math anxiety for students who freeze when confronted with a mathematics problem; it brings to the surface the negative feelings and thoughts that lower confidence and performance (Zaslavsky, 1994). Students draw a vertical line down the center of the paper, solve the problem on one side, and write feelings and thoughts on the other side for each step. Even if the student gets stuck on the problem, writing gives them something constructive to do instead of giving up, and with time the student may get an idea on how to solve the mathematics problem.

To ease frustration with mathematics, informally writing in a mathematics journal gives students an opportunity to freely express their frustrations, clarify new concepts, question unclear concepts, and explain concepts for deeper understanding (Stuart, 2000). Teachers can suggest topics—such as questions or confusion regarding the day's lesson, what was easy or difficult, and what was learned—or allow students to write whatever they want. Some students who do not like to speak up in front of a class might be more willing to write about things they do not understand. According to Burns, writing is valuable in two ways: it helps students make sense of mathematics, and it helps teachers understand what their students are learning (1995).

Writing in mathematics also functions as a connection between mathematics and language arts, in which students experience that subjects in school are not mutually exclusive. In addition to the informal writing that journals and double-entry notebooks offer, students can use their formal writing skills in mathematics class as well. Stuart (2000, p. 334) outlines a few topics for formal writing in mathematics:

1. Students may receive prompts from fictitious businesses that need the class to solve problems related to the current topic; students would then write letters back to the businesses to explain their solutions.
2. Students can write compare and contrast papers about mathematical concepts (such as area and volume).
3. Students can write fictional stories about geometric figures, describing their essential attributes.
4. Students may write their own mathematical problems, illustrate, make an answer key, and then exchange problems with peers to solve.

These possibilities for formal writing in mathematics class serve as a starting point to help teachers tie mathematics to other curricular areas. In addition, informal writing will help students discover what they know and do not know about the mathematics they are learning.

Encourage Positive Self-Talk

One of the benefits from writing in a mathematics journal or double-entry notebook is the student recognizes his or her self-talk, which is what people say to themselves when completing a task (Tobias, 1993). Negative self-talk leads to increased frustration, and "the inability to handle frustration contributes to math anxiety" (Tobias, p. 69). In order alleviate the effects of math anxiety and prevent the anxiety from taking over, students should be taught to replace negative self-talk with positive self-talk (Curtain-Phillips, 1999; Kitchens, 1995; Ruedy & Nirenberg, 1990; Steele & Arth, 1998; Zaslavsky, 1994). Kitchens highlights examples of negative self-talk:

1. I'm the only one who doesn't understand.
2. If she calls on me, I'll die!
3. It might as well be Greek. What's the use?
4. I wish I could get out of this.
5. I get so frustrated. Why do I need this anyway?
6. I hate math.
7. I never could do math.

and examples of positive self-talk those comments should be changed to:

1. …The *only* one?
2. …OK, OK, I won't *die* if she calls on me.
3. …Oh stop! Ask a question, and give it a chance.
4. …I can't get out of this. I can and I will do this.

5. ...I need this for a degree. I need this to show myself that I can do it. The only reason I keep asking "why do I need this" is because I'm so frustrated.
6. ...Why do I hate math? Have I been saying this for so long that I don't even think about it anymore? Give it a chance.
7. ...Give myself a renewed chance. Maybe I *can* do it (1995, p. 13).

Students should be made aware of these comments they make during their self-talk, so they can consciously change them to be positive. To gain confidence in one's ability to be successful at mathematics, Ruedy and Nirenberg suggest repeating the phrase "I am brilliant" silently, out loud, or on paper (p. 65). Writing in journals and double-entry notebooks will also make their negative self-talk evident to students. It is important to emphasize positive self-talk and discourage negative self-talk in order to prevent math anxiety.

Reduce Factors Causing Test Anxiety

Since test anxiety contributes to math anxiety in students, one way to alleviate the damaging effects of math anxiety would be to eliminate the causes of test anxiety in the mathematics classroom. To do this, teachers should make the testing environment less intimidating (Cornell, 1999; Furner & Duffy, 2002; Haynes et al., 2004; Jackson & Leffingwell, 1999; Steele & Arth, 1998). One way to do this would be to weigh test scores less heavily in the final grade, which would lower both test anxiety and math anxiety. Another way to make assessment less intimidating would be to include alternatives to paper and pencil tests: journals, portfolios, interviews, observations, and self-reflections (Furner & Duffy). Instructors can also give students written and verbal reviews before a test, as well as offer alternative test times (before or after school) for students who feel anxiety from time constraints (Jackson & Leffingwell). Tobias suggests that slowing the rate and changing the pattern of breathing during high-anxiety situations will calm students (1993).

Supon recommends that teachers prepare students for testing by teaching them study skills as well as test-taking skills, giving practice tasks similar to test items, and stressing that the purpose of tests are to improve learning (2004). Also, giving students tips for taking tests can reduce their anxiety. It might be beneficial to have these tips on a poster in the classroom so that students will always have reminders to help them cope with their anxiety. According to Curtain-Phillips (1999), these are useful test-taking tips:(a) read through the test entirely before beginning, (b) do the easiest problems first, then go back to do the harder ones, (c) read a problem and plan how to solve before starting, (d) solve multiple-choice questions before looking at the possible answers, (e) make sure to use answer sheets correctly, (f) answer ALL questions—there is usually no penalty for guessing, (g) eliminate the obviously wrong answers first, (h) ask yourself if an answer is reasonable/estimate the answer, (i) stay calm and do not daydream, (j) have a positive attitude and believe you can do it!, (k) use scratch paper, (l) look for key words, (m) circle what the question is asking and answer that question, (n) check all answers, (o) keep your work neat and show all your work, (p) double-check calculations with a calculator, if possible, and (q) do not spend too much time on one problem.

When giving a test in class, there are a couple of things teachers can do to ease testing and math anxiety. Having students turn in all tests at the same time would be beneficial to all students, whether anxious or not (Curtain-Phillips, 1999). Some anxiety comes from seeing other students stand up and hand in the test quickly; the slower students may panic, doubt their abilities, and wonder what they are doing wrong that they have not finished yet. The faster students may make careless mistakes just to be one of the first ones done. To prevent this situation, hand out an enrichment activity along with the test that students can work on when they have finished. The benefits are that more advanced students are given a chance for further study, while the slower students do not know when others in the class have finished.

Timed tests have been a cause for anxiety for many students over many years, and according to Zaslavsky (1994) and Burns (1998), timed tests are especially problematic for some students. "Simply removing time limits from tests may reduce math anxiety" (Haynes et al., 2004, p. 312). The common worksheets with rows and columns of multiplication, division, or some other type of exercise do not have to be abolished altogether; students can benefit from drill and practice. The key is to not set a time limit—let students work at their own pace. Reducing this damaging test anxiety may in turn lower math anxiety.

Give Students Control of Their Learning

For students to be confident in their ability to do mathematics, therefore lowering their math anxiety, they need to take control of their own learning (Furner & Duffy, 2002; Kitchens, 1995; Steele & Arth, 1998; Stuart, 2000; Tobias, 1993; Zaslavsky, 1993) and make sense of new ideas in their own way (Burns, 1998). To do this, students cannot approach mathematics by trying to memorize everything, because that is not possible. Giving students some control in their mathematics education helps students realize their strengths and weaknesses, which is empowering because they are the ones who have the knowledge to improve (Stuart). Meeting with students individually about their daily work and test results—both in class and standardized—to identify both their strong and weak areas of mathematics will allow students to gain that knowledge and control over their own learning. The ultimate goal of mathematics instructors should be to make students into independent learners who are not dependent on the teacher or mathematics book for guidance (Tobias).

Students will more likely take control of their learning by doing their mathematics homework if they understand why homework is necessary. Giving homework is one key way of exposing children to mathematics. Class time is not always available for students to practice the new skills and concepts learned in class. In order for homework to be an effective method of learning, students should know the main purposes of homework, as stated by Curtain-Phillips (1999): (a) to help reinforce what was learned in class, (b) to help identify parts of a lesson that were not understood, and (c) to increase the number of correctly solved problems that students can review for a test. To be an effect means of learning, students must show all their work on their homework, so if a mistake is made, the error can be found and corrected. If the student just writes down a number for the answer, the teacher and the student cannot see where a computational error was made. Students must take control of their own learning in order to reach the highest possible level of success in mathematics.

Dispel Stereotypes

To prevent math anxiety in students today, mathematics teachers should make the effort to dispel stereotypes of who is 'able to do mathematics' and 'who is not able to do mathematics'. The results from Ma and Xu (2004) indicate that there are no statistical gender differences between males and females in mathematical achievement or math anxiety. Therefore, teachers, as well as society, should debunk any stereotypes and convince students that everyone can be successful at mathematics if they work hard (Haynes et al., 2004; NCTM, 2000; Tobias, 1993; Zaslavsky, 1994). There is no 'math gene' that enables some and prevents others to be successful at mathematics. Mathematical understanding takes time and patience—it rarely comes instantly. Everyone can do mathematics. Gender, race, and socio-economic status do not determine who will be more successful in mathematics. Students need to be aware of these stereotypes, so that they will not internalize them and let them rule their mathematical confidence (Perry, 2004); therefore, teachers' actions and comments in the classroom should dispel stereotypes of low expectations for any student.

Involve Parents

Parents can contribute to their children's chances of developing math anxiety; therefore, involving parents in their children's mathematics education is vital (Albrecht, 2006; Burns, 1998; Fotoples, 2000; Prescott, 2001; Zaslavsky, 1994). Parental involvement is critical for students to have a positive attitude towards mathematics (Furner & Duffy, 2002). Teachers should encourage parents to help their children understand difficult concepts and review at home before tests and quizzes to show their children the importance and relevance of mathematics, and also to reinforce what the teacher is doing at school.

Teachers have the opportunity to begin involving parents at the first back-to-school night or conferences by discussing homework procedures and policies, and it gives parents the guidelines for working with their children at home (Burns, 1998). The goal is to have parents listen to the children's ideas and ask questions rather than just give answers. Later in the school year, teachers and students could organize a math fair, at which students would make presentations and perform hands-on activities for family members (Curtain-Phillips, 1999). It is essential for teachers to involve parents in mathematics education in order to be successful at preventing math anxiety in students.

Chapter 3 has listed many prevention methods for mathematics educators to consider. All have been cited numerous times in math anxiety research, and the nine methods cited most often can be found in descending order in the Appendix. The reason that nine prevention methods were chosen as most important is because after the ninth most cited method, four methods tied for number ten with the same number of citations. Therefore, a tenth method could not be determined.

Conclusion

By identifying the components of math anxiety (definition, characteristics, symptoms, and significance to teachers) one can begin to understand how this anxiety towards mathematics affects people. The nature of mathematics is complex, and that may be a possible cause for anxiety. Additional causes include low achievement, anxiety about testing, teachers, parents, and myths about who can be successful at mathematics. After identifying causes of math anxiety, the next important step for teachers is to take actions to prevent it.

The results of a survey done by Stuart (2000) have important implications for teachers of mathematics. For the survey, students were asked to relate their best and worst experiences in mathematics classes. Students related their best experiences to teacher praise, good grades, overcoming a mathematical difficulty, and receiving awards; the worst experiences were related to criticism, failure, and looming difficulties to still overcome. Students were then asked for what they would change about mathematics classes. The answers were conflicting, which gives the following message for teachers: there is no single approach that is best for all students. Some of the things students would like to change: more independent work, less independent work, make math classes harder and longer, make math classes shorter and easier, and asking questions that require students to "think" more to find an answer. Preventing math anxiety has no simple solution; each student, and therefore each class, will have different learning needs. It is up to teachers to determine the best methods to prevent math anxiety for their own students.

In today's globally competitive and highly technological society, it is essential that students in our country have ability and confidence in mathematics. Knowledge of mathematical concepts and tools to solve problems are necessary to succeed, and math anxiety can severely affect students' knowledge and performance. Since math anxiety is complex, there are no simple solutions. Both teachers and students need to acknowledge students' difficulties with mathematics and try to overcome them. This requires effort on both the part of the teacher and the student; the student must ask for help when assistance is needed. Since there is no evidence stating that the cause for math anxiety lies entirely on teachers, it's prevention should not lie entirely in the hands of teachers; however, teachers do play a large part in either preventing or causing math anxiety in their students. To be successful in mathematics, students also must put forth the effort in the learning process.

With a definition of math anxiety, possible causes, and suggested prevention methods, teachers of mathematics can use this resource in the appendix to examine their own teaching and identify methods or attitudes which may be contributing to math anxiety in students. Parents, teachers, students, and society need to strive to eliminate the false stereotypes out there affecting students' perceived ability to be successful at mathematics, because only then will all students realize that they can succeed at mathematics if they work hard at it. Mathematics is important to everyone, and we must work together to minimize math anxiety in our schools and society.

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Appendix

This appendix contains the portion of my research I plan to submit to *The Mathematics Educator* publication and highlights the nine most frequently cited prevention methods of math anxiety.

How To Prevent Math Anxiety in the Elementary Classroom

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Abstract

An anxiety towards mathematics is common in our students today. Math anxiety includes negative feelings about mathematics, feelings of inadequacy, and general fear and avoidance of mathematics, as defined by Zaslavsky (1994). Math anxiety is a significant issue faced by many Americans; as Tobias (1993) states, low performance and fear of mathematics prevents millions of people from pursuing personal and professional opportunities. There are many possible causes of this anxiety, but its roots can often be traced to unsuccessful or negative experiences with mathematics in school. Elementary mathematics teachers have a unique advantage and responsibility to provide children with positive mathematical experiences to prevent or reduce the presence of math anxiety. This article identifies nine strategies for mathematics teachers to counter math anxiety.

How To Prevent Math Anxiety in the Elementary Classroom

It is all too common in our society to hear people say, "I hate math," or "I am just no good at math," while others feel relaxed and competent with mathematics (Stuart, 2005). In a written-response survey given to 157 students in a senior-level elementary mathematics class for prospective teachers, Jackson and Leffingwell found that only seven percent of those surveyed had positive experiences with mathematics from kindergarten to college (1999). This indicates that many people in this country have negative or neutral feelings towards mathematics or lack confidence in their ability to do mathematics. Whatever the statistics may be, there is a definite problem in the area of mathematics that teachers, especially, need to address. Teachers should be teaching not only the content, but also critical thinking; however, without the skills to think critically about mathematics, many middle level students suffer from what is known as math anxiety (Steele & Arth, 1998).

Math anxiety, as defined by Zaslavsky (1994), includes negative feelings about mathematics, feelings of inadequacy, and a general fear and avoidance of mathematics. These feelings come to interfere with a math-anxious person's ability to successfully work with numbers, and that person will eventually view mathematics as a punishment because it brings such high levels of stress. According to Tobias (1993), people who suffer from math anxiety remember a feeling of sudden death, followed by feelings of fear and paranoia. This fear creates an obsession to not make mistakes and not look incompetent in front of peers. Paranoia follows, and the victim believes that everyone else in the class and the teacher know he or she does not understand. Due to the paranoia, they feel they cannot ask questions, or everyone will see how 'dumb they are.' This fear and paranoia can be harmful to students—the fear of exposure—and young adults are especially fearful of exposure (Tobias, 1993). Researchers such as Stuart (2005) and Ma and Xu (2004), indicate that both Zaslavsky's and Tobias's definitions of math anxiety are still accurate today.

Students with high math anxiety tend to take fewer mathematics classes in high school and show less interest in taking mathematics in college; they also tend to drop out of mathematics classes without finishing more often than non-math-anxious students (Hembree, 1990). These students show low confidence in their ability to succeed at mathematics, they take the minimum mathematics required, and they are less prepared for a society that increasingly places higher demands on mathematical literacy (Steele & Arth, 1998). Employers today, in an ever-changing technological world, are finding that the level of mathematical ability that had been adequate in the past is no longer sufficient—"Given this increased demand for math skills, a significant number of people are confronting a renewed fear of math: This fear may be imagined or triggered by anxiety-provoking items such as equations, the use of variables, or vocabulary" (Fotoples, 2000, p. 149). Math anxiety can even influence peoples' career choices. Those with high levels of math anxiety may avoid majors dealing with mathematics in college or careers that require number skills; if math-anxious people go into teaching, it is probable that they will dislike teaching mathematics (Ma, 1999).

Symptoms of math anxiety may differ, but Curtain-Phillips (1999) lists how initial panic will usually lead to the inability to continue. First, panic sets in and brings on an intense pressure to find the correct answer. Next, tension builds from the time gone by and a lack of self-confidence leads to uncertainty. Forgetfulness sets in, and the victim doubts his or her own intelligence to solve the problem. Finally, the victim cannot think rationally about the problem anymore, and the pencil stops moving.

Math anxiety can range from moderate test anxiety to extreme math anxiety, the latter of which is associated with physiological symptoms (Perry, 2004). The moderate test anxiety, when it applies to math testing, is what happens when a student understands mathematical concepts in class and while doing homework assignments but panics and is unable to perform on tests. Therefore, the math anxiety these students suffer is restricted to mathematical testing situations. Moderate levels of math anxiety fall between the two extremes. High math anxiety is the type that is most easily recognized; the extreme cases of math anxiety bring about physiological reactions such as sweating, nausea, headaches, and dry mouth (Fotoples, 2000). Additional possible physiological symptoms may include increased heart rate and paralysis of thought (Perry, 2004). Once a person reaches a high level of math anxiety, it may be difficult to eliminate that anxiety. Teachers should practice prevention methods, so students will not reach this level.

Review of the math anxiety literature identified nineteen ways that mathematics teachers can effectively prevent and/or reduce math anxiety in students (see Table A1). The nine prevention methods cited most frequently were chosen as the most important strategies that mathematics teachers can do to prevent math anxiety. The reason nine were chosen is because after the ninth, four methods had the same number of citations; therefore, a tenth method could not be easily determined. The top nine ways for mathematics teachers to prevent math anxiety in students are listed in descending order and described in detail.

Table A 1

Frequency That Prevention Methods were Cited

Prevention Method	Frequency
Acknowledge multiple learning styles	13
Cooperative groups and peer tutors	11
Relate to students' lives, other subjects, and prior knowledge	11
Use manipulatives to teach concretely	10
Reduce factors causing test anxiety	9
Emphasize concepts and problem solving	9
Write in mathematics class	8
Give students control of their learning	7
Do not embarrass students	7
Dispel stereotypes	6
Encourage positive self-talk	6
Patience and a positive attitude	6
Do not go too fast	6
Involve parents	5
Make mathematics experiences successful	5

Encourage students to ask questions	5
Teach how to read mathematical text	5
Talk about frustrations and anxiety	4
Equity for all students	3

Note. 24 books and journal articles were consulted.

1. *Acknowledge Multiple Learning Styles*

Providing multiple learning experiences for students will acknowledge different learning styles. Students who are strong in the visual and spatial intelligence will appreciate bulletin boards, posters, pictures, charts, graphs, diagrams, films, slides, and models portraying mathematical concepts (Curtain-Phillips, 1999). Visual learners will also benefit from information written on the board, written directions, drawings and diagrams, using computer software and Internet, while verbal/auditory learners will understand concepts best when they are explained by a teacher or someone else—they should be encouraged to ask many questions to clarify any confusion (Fotoples, 2000). Students who are strong kinesthetic learners may also profit from activities in mathematics class: manipulatives, role playing, and simulations (Curtain-Phillips). Fotoples also suggests concrete ways of learning, or manipulatives, to aid those kinesthetic learners, such as measuring tools and beads or beans for counting. It is up to teachers to help students find what works best for them to learn mathematics successfully.

Since equity for all students is an important goal in the teaching and learning of mathematics, educators need to consider the different learning styles of students when planning for instruction. Students learn in many different ways, as Gardner

(1993) outlines in his theory of multiple intelligences, so instructors need to explain concepts in more than one way; this will lead to greater chances that all students will understand—and understand more deeply (Cornell, 1999; Curtain-Phillips, 1999; Farrell, 2006; Fotoples, 2000; Furner & Duffy, 2002; Furner, Yahya, & Duffy, 2005; Ma & Xu, 2004; Sloan, Daane, & Giesen, 2002). Teachers should not limit their teaching methods to those preferred by students strong in the linguistic intelligence and logical-mathematical intelligence, or they will run into the danger of not providing an equal chance for all to learn mathematics. In addition to the linguistic and logical-mathematical intelligences, Gardner identifies musical, bodily-kinesthetic, spatial, interpersonal, and intrapersonal intelligences; students may be strong in one or more of Gardner's other five intelligences and benefit from many different activities designed especially for their best way of learning.

According to Zaslavsky (1994), teachers have many factors to consider when planning for instruction which accounts for different learning styles. To prevent teaching only to the linguistic intelligent and logical-mathematical students, teachers should keep in mind students': (a) preferences for working alone or in a group, (b) preferences for a competitive or cooperative environment, (c) preferences for written or oral instruction, (d) strategies for tackling a new problem, (e) speeds at which they work, (f) individual attitudes and need for outside encouragement, (g) aptitudes for taking risks, and (h) impulsive versus reflective styles. For example, teachers can acknowledge students' preferences for working alone or in a group by designing learning tasks in which students work in groups on some tasks and alone on other tasks; the teacher cannot meet the needs of both types of students at the same time but can meet their needs at least part of the time. If these differences are not acknowledged, students will be frustrated with the learning environment as well as themselves.

Since students do learn in different ways, they will also find their answers to problems in many different ways, depending on their style of learning; some will find an answer by following a procedure step-by-step, while other students may know how to identify and solve a problem using a broad sense of knowledge (Burns, 1992; Fotoples, 2000; Ruedy & Nirenberg, 1990; Tobias, 1993). Burns suggests giving students mathematical problems that have several possible ways of solving and encouraging them to share their solutions with classmates. By doing this, students will see and hear different approaches, which reinforces that there is more than one way to solve problems, and they will learn to value their own way of thinking. It is imperative that teachers value each student's method of reasoning, as well as allow flexibility in how students reach solutions and express their solutions. This will lead to increased participation and confidence in students, along with lower levels of stress and anxiety which stem from trying to solve a problem the way the teacher or book wants (Steele & Arth, 1998). By providing multiple learning experiences and expecting more than one way to solve a problem, teachers can help prevent math anxiety.

2. *Cooperative Groups and Peer Tutors*

To maximize learning and emphasize cooperation over competition, students should be given opportunities to work with cooperative groups or peer tutors (Cornell, 1999; Curtain-Phillips, 1999; Fotoples, 2000; Furner & Duffy, 2002; Furner et al., 2005; Ma & Xu, 2004; Prescott, 2001; Steele & Arth, 1998; Stuart, 2000; Tobias, 1993; Zaslavsky, 1994). In cooperative learning groups, a student may use a term or explanation that the teacher did not think of which may be exactly what another student needed to understand the concept; cooperative learning benefits all students because it is reassuring to know that others have difficulty with mathematics also. For students who are anxious about sharing or asking questions in front of the whole class, small groups will allow them to ask questions more freely, exchange ideas, clarify concepts, and help each other understand ideas in meaningful ways (Curtain-Phillips, 1999). Math anxiety can be caused by the frustration of working alone and getting stuck, so cooperative groups reduce the feeling of isolation.

In a survey by Stuart (2000), some students indicated a dislike towards working in groups due to concerns that one person would do all the work or the group would not get along. Before allowing students to work in cooperative groups, teachers should address these concerns by making their expectations of students' contribution to the group clear in order to prevent those situations from occurring; teachers can also explain that working with people one does not get along with is a part of life and a part of school. Overall, cooperative groups and peer tutors reinforce cooperation over competition and help lower anxiety caused by feelings of isolation.

3. *Relate to Students' Lives, Other Subjects, and Prior Knowledge*

To maximize student comprehension, mathematics teachers need to make connections between the mathematics students are learning in class and their world around them, so they will construct personal knowledge of the information (Furner et al., 2005; Steele & Arth, 1998; Zaslavsky, 1994). According to Zaslavsky, "the majority of students are not enjoying the 'real math' that would be meaningful to them. In the early grades children are expected to learn mathematical words and symbols, and to master paper-and-pencil procedures...since they see no connection between these procedures and the real world, it all makes little sense to them" (1994. p. 135). Instructors should strive to provide opportunities to learn mathematics in open-ended ways that are interesting and motivating to students, in which they also must think logically and put knowledge together in new ways to solve problems (Steele & Arth, 1998).

In addition to relating mathematics to the worlds of students, mathematics instruction should be related to prior knowledge and other subject areas. Unless new information is associated with knowledge students already possess, it will not have meaning for students (Albrecht, 2006; Brady & Bowd, 2005; Burns, 1998; Furner & Duffy, 2002; Furner et al., 2005; NCTM, 2000; Perry, 2004; Prescott, 2001; Steele & Arth, 1998). Mathematics should not be taught in isolation from other subjects—if students can make connections to science, social studies, writing, and reading, for example, they more likely will remember and apply the new information (Furner & Duffy, 2002; Stuart, 2000). According to Stuart, students can use mathematical skills in science by calculating results for experiments and constructing tables and graphs; also, in social studies mathematical skills are used when drawing maps to scale and calculating differences in dates on timelines, for example (2000). Burns suggests motivating students by connecting mathematics to children's literature; books contain imaginative ideas that can lead to problem-solving situations (1992). By using children's books to create interest, teachers will encourage young children to reason mathematically in their world.

When considering how to design tasks which relate mathematics to students' lives, teachers should recognize the prevalence of technology and use it accordingly. Not only is proficiency with technology increasingly part of our students' lives, but it is also required to compete with and work with others around the world professionally (Cornell, 1999; Burns, 1998; Furner & Duffy, 2002). The use of technology in the classroom, including calculators and computers, leads to opportunities for projects, and it also takes away the anxiety and boredom associated with drill-and-practice worksheets while helping students enjoy mathematics. Teachers should allow students to work with mathematical software and/or mathematical websites on the Internet to build their mathematical skills, as well as technological skills; another possibility is to project websites from a computer onto a large screen for the whole class to view (Curtain-Phillips, 1999). Students need to construct their own knowledge of mathematics, it is vital that teachers make connections to students' lives.

4. *Use Manipulatives to Teach Concretely*

To aid students in understanding mathematical concepts and solving problems, it is essential for teachers, especially in the elementary school, to use manipulatives. Young students are not cognitively ready to understand abstract ideas without using concrete objects to see relationships; therefore, manipulatives will help all students grasp abstract concepts (Brady & Bowd, 2005; Burns, 1995; Curtain-Phillips, 1999; Furner & Duffy, 2002; Furner et al., 2005; Ma & Xu, 2004; Steele &

Arth, 1998; Tobias, 1993; Zaskavsky, 1994). Manipulatives are concrete materials which help students develop conceptual knowledge of mathematical concepts, and using them in the classroom makes pedagogical sense. A young child holding three blocks in one hand and four in the other can 'feel' seven blocks; however, there is no saying that the child will make the same connection when he or she sees the symbols 3 + 4 (Tobias, 1993). Also, students tend to forget things that are only taught abstractly, which can lead to frustration. Manipulatives offer something different from the textbook's abstract method of teaching and when used in small cooperative groups will appeal to students who are strong in the interpersonal intelligence (Curtain-Phillips, 1999).

In a survey conducted by Stuart (2000), three-fourths of students asked said that manipulatives were helpful when learning a new concept. Manipulatives, which can be everyday objects as well as those commercially made, used in classrooms may include: money, color counters, rulers, calculators, number cubes, dominoes, playing cards, buttons, tangrams, fraction manipulatives, geoboards, pattern blocks, Cuisenaire rods, miras, unifix cubes, and base ten blocks. Using manipulatives requires more planning and organization on the part of the teacher, but students will most likely take a greater interest in their class work, as well as mathematics in general.

5. *Reduce Factors Causing Test Anxiety*

Since test anxiety contributes to math anxiety in students, one way to alleviate the damaging effects of math anxiety would be to eliminate the causes of test anxiety in the mathematics classroom. To do this, teachers should make the testing environment less intimidating (Cornell, 1999; Furner & Duffy, 2002; Haynes, Mullins, & Stein, 2004; Jackson & Leffingwell, 1999; Steele & Arth, 1998). One way to do this would be to weigh test scores less heavily in the final grade, which would lower both test anxiety and math anxiety. Another way to make assessment less intimidating would be to include alternatives to paper and pencil tests: journals, portfolios, interviews, observations, and self-reflections (Furner & Duffy). Instructors can also give students written and verbal reviews before a test, as well as offer alternative test times (before or after school) for students who feel anxiety from time constraints (Jackson & Leffingwell). Tobias suggests that slowing the rate and changing the pattern of breathing during high-anxiety situations will calm students (1993).

Supon recommends that teachers prepare students for testing by teaching them study skills as well as test-taking skills, giving practice tasks similar to test items, and stressing that the purpose of tests are to improve learning (2004). Also, giving students tips for taking tests can reduce their anxiety. It might be beneficial to have these tips on a poster in the classroom so that students will always have reminders to help them cope with their anxiety. According to Curtain-Phillips (1999), these are useful test-taking tips: (a) read through the test entirely before beginning, (b) do the easiest problems first, then go back to do the harder ones, (c) read a problem and plan how to solve before starting, (d) solve multiple-choice questions before looking at the possible answers, (e) make sure to use answer sheets correctly, (f) answer ALL questions—there is usually no penalty for guessing, (g) eliminate the obviously wrong answers first, (h) ask yourself if an answer is reasonable/estimate the answer,

(i) stay calm and do not daydream, (j) have a positive attitude and believe you can do it!, (k) use scratch paper, (l) look for key words, (m) circle what the question is asking and answer that question, (n) check all answers, (o) keep your work neat and show all your work, (p) double-check calculations with a calculator, if possible, and (q) do not spend too much time on one problem.

When giving a test in class, there are a couple of things teachers can do to ease testing and math anxiety. Having students turn in all tests at the same time would be beneficial to all students, whether anxious or not (Curtain-Phillips, 1999). Some anxiety comes from seeing other students stand up and hand in the test quickly; the slower students may panic, doubt their abilities, and wonder what they are doing wrong that they have not finished yet. The faster students may make careless mistakes just to be one of the first ones done. To prevent this situation, hand out an enrichment activity along with the test that students can work on when they have finished. The benefits are that more advanced students are given a chance for further study, while the slower students do not know when others in the class have finished.

Timed tests have been a cause for anxiety for many students over many years, and according to Zaslavsky (1994) and Burns (1998), timed tests are especially problematic for some students. "Simply removing time limits from tests may reduce math anxiety" (Haynes et al., 2004, p. 312). The common worksheets with rows and columns of multiplication, division, or some other type of exercise do not have to be abolished altogether; students can benefit from drill and practice. The key is to not set a time limit—let students work at their own pace. Reducing this damaging test anxiety can lower math anxiety.

6. *Emphasize Concepts and Problem Solving*

By emphasizing mathematical concepts and problem solving over simple computations, students will gain a more comprehensive knowledge of mathematics. Even for young children, mathematics is more than just arithmetic and memorization—they should be exposed to all areas of mathematics (Brady & Bowd, 2005; Burns, 1995; Prescott 2001). The National Council of Teachers of Mathematics identifies ten areas of mathematics, or standards, to which students should be exposed: Number and Operations, Algebra, Geometry, Measurement, Data Analysis & Probability, Problem Solving, Reasoning and Proof, Communication, Connections, and Representation (2000). If students can only perform mathematical exercises as outlined in their homework problems without understanding the broad concept, they will not be able to apply the concept to other situations. Closely related to understanding concepts is understanding how to solve mathematical problems. According to Tobias (1993), word problems, or story problems, are at the heart of math anxiety. Therefore, children need to learn strategies for solving word problems, if we do not want them to grow up avoiding mathematics (Burns, 1998; Cornell, 1999; Furner & Duffy, 2002; Ma & Xu, 2004; Stuart, 2000; Tobias, 1993; Zaslavsky, 1994).

Strategies for solving problems should be discussed by teachers and students, and teachers should give students plenty of opportunities to put these strategies into practice. A few strategies include: (a) drawing a picture or diagram to illustrate the problem, (b) turning big numbers into smaller numbers so a method for solving may become apparent, (c) estimating an answer so the final solution may be judged as appropriate compared to an estimated answer, and (d) using logic or common sense (Tobias, 1993).

Additional strategies for problem solving, given by Furner, Yahya, and Duffy, are work backwards, look for a pattern, use trial and error, act it out, and use a table to organize data (2005). Zasklavsky suggests listing the given facts and relationships between them, relating the problem to other mathematical ideas, and checking the solution for reasonability (1994). Ruedy and Nirenberg (1990) highlight six strategies for problem-solving:

1. Breathe.
2. Read questions in small segments, lifting your head and integrating information at each stop.
3. Draw a picture if at all applicable. Use circles and bricks.
4. Rewrite the problem in your own words.
5. Give an off-the-top-of-the-head estimate of the answer.
6. Simplify the problem and do a simplified version first (p. 162).

It would be helpful to students if teachers would visibly display problem-solving strategies in the classroom, such as Polya's four-step process: understand the problem, then devise a plan, next carry out the plan, and look back (Musser, Burger, & Peterson, 2001). When students and teachers strive for concept understanding and examine how problems are solved, rather than just correct answers, students will become less worried about making mistakes and, therefore, better problem-solvers (Steele & Arth, 1998).

7. *Write in Mathematics Class*

To some, mathematics and writing may seem like oil and water—that is, mathematics is all numbers and has nothing in common with writing; however, writing about mathematics can help students find out what they know and what they do not know, as well as help them think more deeply about their own learning (Burns, 1995). Writing in mathematics class can take many forms, such as journals and double-entry notebooks to written solutions to problems, but whatever the format, students will benefit from transmitting their thoughts and feelings to paper (Curtain-Phillips, 1999; Prescott, 2001; Ruedy & Nirenberg, 1990; Steele & Arth, 1998; Stuart, 2000; Zaslavsky, 1994). For elementary students in the primary grades, who cannot write about mathematics, encouraging them to think out loud while working on mathematics is an effective way for them and others to catch mistakes (Furner et al., 2005). Students with lower writing abilities could accomplish this task by keeping an audio journal, in which they recorded their thoughts and feelings into a tape recorder (Furner & Duffy, 2002).

Writing in a double-entry notebook can ease math anxiety for students who freeze when confronted with a mathematics problem; it brings to the surface the negative feelings and thoughts that lower confidence and performance (Zaslavsky, 1994). Students draw a vertical line down the center of the paper, solve the problem on one side, and write feelings and thoughts on the other side for each step. Even if the student gets stuck on the problem, writing gives them something constructive to do instead of giving up, and with time the student may get an idea on how to solve the mathematics problem.

To ease frustration with mathematics, informally writing in a mathematics journal gives students an opportunity to freely express their frustrations, clarify new concepts, question unclear concepts, and explain concepts for deeper understanding (Stuart, 2000). Teachers can suggest topics—such as questions or confusion regarding the day's lesson, what was easy or difficult, and what was learned—or allow students to write whatever they want. Some students who do not like to speak up in class might be more willing to write about things they do not understand. According to Burns, writing is valuable in two ways: it helps students make sense of mathematics, and it helps teachers understand what their students are learning (1995).

Writing in mathematics also functions as a connection between mathematics and language arts, in which students experience that subjects in school are not mutually exclusive. In addition to the informal writing that journals and double-entry notebooks offer, students can use their formal writing skills in mathematics class as well. Stuart (2000, p. 334) outlines a few topics for formal writing in mathematics:

1. Students may receive prompts from fictitious businesses that need the class to solve problems related to the current topic; students would then write letters back to the businesses to explain their solutions.
2. Students can write compare and contrast papers about mathematical concepts (such as area and volume).
3. Students can write fictional stories about geometric figures, describing their essential attributes.
4. Students may write their own mathematical problems, illustrate, make an answer key, and then exchange problems with peers to solve.

These possibilities for formal writing in mathematics class serve as a starting point to help teachers tie mathematics to other curricular areas. In addition, informal writing will help students discover what they know and do not know about the mathematics they are learning.

8. *Give Students Control of Their Learning*

For students to be confident in their ability to do mathematics, thereby lowering their math anxiety, they need to take control of their own learning (Furner & Duffy, 2002; Steele & Arth, 1998; Stuart, 2000; Tobias, 1993; Zaslavsky, 1993) and make sense of new ideas in their own way (Burns, 1998). To do this, students cannot approach mathematics by trying to memorize everything, because that is not possible. Giving students some control in their mathematics education helps students realize their strengths and weaknesses, which is empowering because they are the ones who have the knowledge to improve (Stuart). Meeting with students individually about their daily work and test results—both in class and standardized—to identify both their strong and weak areas of mathematics will allow students to gain that knowledge and control over their own learning. The ultimate goal of mathematics instructors should be to train students to become independent learners who are not dependent on the teacher or mathematics book for guidance (Tobias).

Students will more likely take control of their learning by doing their mathematics homework if they understand why homework is necessary. Giving homework is one key way of exposing children to mathematics. Classtime is not always available for students to practice the new skills and concepts learned in class. In order for homework to be an effective method of learning, students should know the main purposes of homework, as stated by Curtain-Phillips (1999): (a) to help reinforce what was learned in class, (b) to help identify parts of a lesson that were not understood, and (c) to increase the number of correctly solved problems that students can review for a test. To be an effective means of learning, students must show all their work on their homework, so if a mistake is made, the error can be found and corrected. If the student just writes down a number for the answer, the teacher and the student cannot see where a computational error was made. Students must take control of their own learning in order to reach the highest possible level of success in mathematics.

9. *Do Not Embarrass Students*

Many math-anxious students and adults can recall how they were embarrassed in mathematics class, which can be a significant cause of math anxiety. These words from Alisa demonstrate the lasting impressions of early embarrassment:

> She called on me to stand up and say the twos [multiplication facts]. Well I stood up and started. I said two times one. And I couldn't remember anymore and I stood up there trying to remember and then I was so embarrassed I started to cry. She let me sit down and she told me to stop crying. That's all I remember about third grade (Burns, 1995, p. 7).

Therefore, to prevent math anxiety, teachers should make a conscious effort not to embarrass or single-out students in class (Cornell, 1999; Curtain-Phillips, 1999; Jackson & Leffingwell, 1999; Perry, 2004; Tobias, 1993).

Choose students to work at the board with caution—some students will see it as punishment or torture and will panic (Steele & Arth, 1998). Students also must realize that the reason they are asked to work at the black/whiteboard is so that everybody in the class can see their procedure and benefit from it. For students who are anxious about going up to work on the board, teachers can allow them to go up in pairs or groups until they feel comfortable. Comments made from a teacher may also embarrass students, even though that was not what the teacher intended; replace comments such as, "this is a better way to do it," with "that method works, and here is another way to do it" (Steele & Arth, 1998, p. 45). Teachers' actions have a profound effect on students' confidence and attitudes toward mathematics, so embarrassing them in class is harmful.

In today's globally competitive and highly technological society, it is essential that students in our country have ability and confidence in mathematics. Knowledge of mathematical concepts and tools to solve problems are necessary to succeed, and math anxiety can severely affect students' knowledge and performance. Since math anxiety is so complex, there are no simple solutions. Both teachers and students need to acknowledge students' math difficulties and try to overcome them. With these nine prevention methods, teachers of mathematics can help to prevent math anxiety in students and give them confidence in their ability to be successful in mathematics.

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