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ANXIETY IN THE MATH CLASSROOM

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ANXIETY IN THE MATH CLASSROOM

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Math anxiety is a learned response that inhibits cognitive performance in the math classroom. It is widespread among students from elementary age through college. Students suffering from math anxiety have difficulty performing calculations and maintaining a positive outlook on mathematics. Math anxiety is the result of a cycle of math avoidance that begins with negative experiences regarding mathematics. Facts pertaining to math anxiety are discussed and strategies are suggested to assist teachers in helping students to overcome math anxiety or avoid the phenomenon altogether.

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Chapter 1: Introduction

An overwhelming proportion of math students insist they "don't get it" or "I'm bad at math." Does this attitude stem from laziness? Defiance? Is it the result of my or my predecessor's teaching style? As a math teacher, I have a common experience with students who appear capable in mathematics but are so apprehensive about the subject they are rendered helpless when it comes to performing tasks independently or on tests. Calm, carefully chosen questions seem to assist these students with a problem or two but their angst returns when they are required to work independently and too many are happy to get by with mediocre performances. In 2005, an Associated Press-America online (AOL) news poll revealed that forty percent of adults claim they *hated* math in school; twice as many as the next most hated subject (Boaler, 2008). Yet recent movies such as Good Will Hunting (1997), A Beautiful Mind (2001) Proof (2005) and even the TV show NUMB3RS indicate that Americans admire mathematics and mathematicians. What is this phenomenon that causes our students' knowledge to dry up and disappear at the most important moment? How can we help our students overcome this difficulty?

A quick Google search for *math phobia* finds an article by Deb Russell on About.com that states, "Math anxiety or fear of math is actually quite common. Math anxiety is quite similar to stagefright. Why does someone suffer stagefright? Fear of something going wrong in front of a crowd? Fear of forgetting the lines? Fear of being judged poorly? Fear of going completely blank? Math anxiety conjures up fear of some type: the fear that one won't be able to do the math or the fear that it's too hard or the fear of failure which often stems from having a lack of confidence. For the most part, math anxiety is the fear about doing the math right, our minds draw a blank and we think we'll

fail and of course the more frustrated and anxious our minds become, the greater the chance for drawing blanks. Added pressure of having time limits on math tests and exams also cause the levels of anxiety to grow for many students."

I am interested in math anxiety as a result of classroom experiences. I have had several students who exhibited physical symptoms such as extreme acne breakouts, dark circles under the eyes, literally trembling as the test loomed. I am also surprised at how many students claim the success in my class is the first they've had in math. I struggle analytically with the idea that a perfectly capable student who demonstrates reasonable mastery was somehow incompetent until they darkened my doorway. In a large math department with ten teachers, many of whom who are teaching the same class with the same text, how is it that the same student can achieve such drastically different performances from one class to the next?

Since Sheila Tobias coined the term *math anxiety* in the late 1970s, much research has been accomplished on the subject. Most sufferers can be identified as exhibiting 'math avoidant' behaviors. Potential causes that have been suggested include dependence on calculators from an early age, curriculum design, emphasis on rote memorization and tedious algorithmic exercises in the primary grades, and shallow teacher understanding (Hilton, 1980).

Significance of the Research Problem

According to Cathy Godby, math anxiety can literally cause a student's thought processes to 'freeze up' or make the student physically ill (Godbey, 1997). Further investigation elaborates; the effects of math anxiety range not only from psychological symptoms such as confusion, uncontrollable uneasiness, panic, preoccupation with

negative thoughts, and sudden memory loss, but also to physiological symptoms such as increased heart rate, sweating, nausea, fainting, stomach disorders, and headaches (Johnson, 2005).

Research has clearly demonstrated a negative correlation between math anxiety levels and math achievement, indicating that higher levels of anxiety coincide with lower achievement levels (Woodard, 2004). Math anxiety is a key component in a vicious cycle of math avoidance. This cycle is defined by Preis and Biggs (2001) as having four phases, where phase one is a negative reaction to math experiences, phase two is avoidance of math situations, phase three is the resulting lack of proper math preparation, and phase four is consequent poor math performance.

The phenomenon is also pervasive. A 1992 study at the University of Florida found that approximately twenty six percent of students had a moderate to high need for help with math anxiety. Another 1998 study declares two thirds of Americans fear and loathe math (Burns, 1998). The most common sufferers of math anxiety are nontraditional students and remedial students; although students who plan to major in careers that require strong math skills are also susceptible. According to Gary Scarpello, math anxiety can begin as early as fourth grade and often peaks in middle school or high school. He points out that in the early grades there is no significant difference in anxiety levels of males and females but in secondary school and college females exhibit more symptoms of math anxiety than males. Thus, the evidence shows that a significant proportion of the student population would perform better if their fears were addressed and their anxiety regarding math reduced.

Statement of the Problem

In these times of educational reform and upheaval, becoming an effective teacher is not only ethically desirable but perhaps essential for job retention. Individual student histories and causes of math anxiety vary widely, but they share many of the same symptoms and outcomes. Millions of adults are blocked from professional and personal opportunities because they fear or perform poorly in mathematics (Tobias, 1993). If we are to encourage as many students as possible to pursue and be successful in math, it is important to acknowledge this facet of mathematics education and seek to remedy it. This paper will attempt to define and describe the most common causes of math anxiety and offer solutions for teachers who must help their students overcome this difficulty.

Research Questions

What is math anxiety and what causes it?

1. How does math anxiety cause students to forget how to do mathematics?
2. How does math anxiety relate to poor math performance?
3. How common is math anxiety?
4. What factors cause math anxiety?

What role do teachers play in math anxiety?

1. How does the classroom environment affect math anxiety?
2. What can teachers do to ease the effects of math anxiety?

Limitations and Assumptions

I am limiting my research to the secondary and college level classroom. I will not attempt to explain the pathology of anxiety disorders except as they pertain to the

learning of mathematics. I will assume that all students who suffer from math anxiety can be helped in some way so that they can achieve practical success in mathematics.

Summary Statement

Math anxiety is a learned response that inhibits cognitive performance in the math classroom. It is widespread among students from elementary age through college. Students suffering from math anxiety have difficulty performing calculations and maintaining a positive outlook on mathematics. Math anxiety is the result of a cycle of math avoidance that begins with negative experiences regarding mathematics. Facts pertaining to math anxiety are discussed and strategies are suggested to assist teachers in helping students to overcome math anxiety or avoid the phenomenon altogether.

Chapter Two: Research

Math anxiety can have a devastating effect on student performance. This research will attempt to define and describe math anxiety, identify teacher behavior variables that contribute to math anxiety, and offer strategies for teachers to help students who suffer from it.

Definition and Effects

Many definitions exist for math anxiety. The concept can be generally defined as the panic, helplessness and anxiety that some individuals experience when required to solve a mathematical problem (Biggs & Preis, 2001). Math anxiety involves a learned emotional response to participating in a math class, listening to a math lecture or working through a math problem (Rossman, 2006). Johnson (2005) indicated that math anxiety is also defined in cognitive terms as a change in the brain's normal processing mechanism that inhibits short-term memory and reasoning functions in response to a situation involving mathematical computations (Johnson, 2005).

Math anxiety can produce physical symptoms that are typical of elevated anxiety levels such as nausea, shortness of breath, and increased blood pressure. It can also produce psychological symptoms such as memory loss, paralysis of thought, and a sense of isolation (Biggs & Preis, 2001). These physical and psychological symptoms interfere with the manipulation of numbers and solving math problems in the classroom and in situations requiring the use of math outside the classroom (Godbey, 1997). Research examining the cognitive functioning of individuals experiencing math anxiety has determined that the anxiety operates as a secondary task demanding cognitive resources,

which reduces the amount of resources such as short-term working memory available to address the math problem (Ashcraft & Krause, 2007).

A common coping mechanism is math avoidance to reduce anxiety levels (Biggs & Preis, 2001). Math avoidance is part of a behavioral reinforcement cycle in which the individual has a negative math experience leading to the avoidance. As a direct result of the avoidance, students do not adequately prepare for mathematics, which results in poor performance, which in turn leads to new negative experiences that encourage continued avoidance. Scarpello (2007) suggested that this negative reinforcement pattern is particularly significant as part of the continuous re-evaluation process among adolescents concerning their ability to be successful in school and may negatively influence choosing a career requiring math skills.

Estimates of the prevalence of math anxiety are varied. According to Burns (1998), approximately two-thirds of American adults and children have math anxiety to some degree. In contrast, research identified by Johnson (2005) indicated that twenty five percent of students have a moderate to high need for assistance with math anxiety. There is also evidence that math anxiety is more common among women and older students, as a result of a longer, more established cycle of poor performance in math (Biggs & Preis, 2001).

Factors Contributing to Math Anxiety

Previous research has established that insufficient preparation is the primary cause of math anxiety, which is attributable to many factors (Godbey, 1997). External factors such as excessive absences from school, teacher and parental attitudes toward math, and classroom emphasis on drill also influence math anxiety. Internal factors such as

individual differences in the ability to deal with frustration and poor self-concept contribute to math anxiety. Johnson (2003) focuses on the internal factors leading to math anxiety, attributing it to poor test preparation, poor test-taking strategies and psychological pressures. For some individuals, deficiencies in inhibition mechanisms such as attention deficit disorder lead to spending an excessive amount of time on distracters that cloud the reasoning process.

Woodard (2004) identified three categories of factors that include both external and internal variables. The first group of factors is environmental and includes the influence of myths, the actions of teachers and the attitude of parents. The second group of factors involves internal intellectual or cognitive capabilities and includes learning styles, self-doubt, and dyslexia. The third group of factors is also internal and involves personality factors such as shyness and low self-esteem. These categories of contributing factors are consistent with Godbey's (1997) argument that math anxiety has multiple causes that vary among individuals.

The majority of discussion of causative factors for math anxiety focuses on the environmental factors identified by Woodard (2004). Popular misconceptions contribute to negative attitudes towards math (Biggs & Preis, 2001). Some of these misconceptions include beliefs that math skills are innate and cannot be learned, that math inhibits creativity, and that women are less capable at math than men. Some of these beliefs are established and perpetuated by parental attitudes towards math (Godbey, 1997; Scarpello, 2007). Tobias (1993) provides anecdotal information suggesting that parents and teachers do not emphasize that math competency is the result of practice and hard work, and often tell students that deficiencies in competency are the result of low ability. It is hard to

imagine a teacher informing a student that they did not do well because they lack intelligence, but this is exactly the message when a teacher praises a students' correct response as being smart instead of praising the students' hard work that resulted in the correct response (Dweck, 2007). For these students, correct answers indicate intelligence and subsequently, failure to arrive at an immediate correct answer implies they are *not* smart. According to Zaslavsky (1996), teachers are also often reluctant to encourage some students to achieve in math if parents do not have high expectations because of gender or socioeconomic beliefs.

The Math Anxiety Rating Scale (MARS) and the shorter Math Anxiety Scale (MAS) are the commonly used instruments to assess the level of math anxiety (Godbey, 1997). Woodard (2004) used the MARS instrument to assess math anxiety among community college students to determine if the demographic factors of age and gender moderate the relationship between math anxiety and achievement. The findings indicated that female students had higher levels of math anxiety than male students. Results also showed that no differences existed in math anxiety levels between traditional and non-traditional students based on age, but non-traditional students had higher levels of math anxiety than traditional students. These findings support the argument of Biggs and Preis (2001) that common beliefs concerning poor math ability among women contributes to differences in math anxiety levels between the genders.

Effect of Teachers on Math Anxiety

While the literature indicates that many factors contribute to math anxiety, it frequently mentions the instructional methods used by teachers as significant in influencing students' attitudes toward math. Cavanaugh (2007), however, noted that there

has been relatively little empirical research examining the effect of classroom instructional methods on math anxiety despite many investigations of the effect of the problem on student performance and cognitive processes. As a result, the majority of the literature offering opinions concerning the effect of teachers for fostering or remedying math anxiety is based on anecdotal evidence.

Zaslavsky (1996) notes that minorities and non native English speakers are often tracked into remedial math courses and are commonly discouraged or prohibited from taking higher level courses. Many of these students are symptomatic of math anxious students when they have never attempted higher math! One study found that the kind of counseling, amount of teacher-student interaction, and administrative leadership have a substantial effect on minority students (Zaslavsky 1996). These students often relate that their high school teachers and counselors made them feel like they could not comprehend or compete with others in grade level math courses, so they were relegated to remedial math courses or 'record keeping' courses which only reinforced the intimidation factor of higher level math. The practice of tracking students based on ability has repeatedly been shown to be ineffective and research frequently suggests cooperative learning groups of mixed ability, with the same expectations for all students, is far more successful yet the practice is still uncommon (Zaslavsky, 1996).

Burns (1998) compares the learning of mathematics to basketball. What if, when learning to play the game, we spent the first year learning only to dribble, the second year learning only to pass, the third year spent exclusively on learning to shoot baskets, and the fourth year learning the rules of the game using worksheets, sitting in a classroom without talking? Surely many students would come to hate basketball. It is this kind of

rote memorization of isolated processes that makes mathematics dull and painful for our students.

Boaler (2008) also argues that this design and presentation of mathematics in schools fosters math anxiety. The standard method of instruction in many math classrooms is a significant factor leading to poor performance, which is the first identified phase of math avoidance and anxiety. In most classrooms, the teacher presents math problems in a didactic manner,[1] with the students disengaged from the learning process and discouraged or prevented from discussing the material or asking meaningful questions. Add to this pressure from the expectation that students must master the concepts and procedures that will be assessed on standardized and high stakes tests, and what evolves is rigidity in curriculum and teaching approaches. Another aspect to note is these standardized tests rely heavily on a multiple choice format, which does not assess understanding of the underlying material.

Mathematics education reform has been met with violent opposition, culminating in the form of 'math wars' beginning in California and subsequently spreading throughout the United States in the early 2000's. Traditionalists argue that 'talking about math' will never replace good old fashioned drill and practice and have even used scare tactics such as convincing students and parents that the new curriculum will prevent them from being successful in college (Boaler, 2008).

According to Rossman (2006), students attempting to memorize algorithmic processes to work through problems without understanding the underlying concepts are more likely to experience math anxiety. While students may be able solve a problem in a

[1] Regarding medicine, didactic means teaching from textbooks rather than laboratory demonstration and clinical application, from *Wiktionary*

contrived textbook context, they may have difficulty applying the knowledge in other situations if they do not understand the fundamental principles involved.

The way textbooks are used in schools may also contribute to poor math performance because math teachers do not teach students how to read math texts, which are often written at a higher reading level than the students can understand without supplementary explanation by the teacher. However, Boaler (2008), points out that studies repeatedly indicate good teachers can make mathematics exciting even with a lackluster textbook and bad teachers do not become good as a result of a well written text.

In some cases, a teacher's poor mastery of the material can increase math anxiety in students because the teacher communicates uncertainty in presentation and in response to questions (Cavanaugh, 2007). In addition, a teacher with poor mastery of the subject or appropriate teaching methods may not be able to remedy the difficulties of students in understanding the material. In her 1999 book, *Knowing and Teaching Elementary Mathematics*, Liping Ma notes the vast difference in the depth of Chinese teachers' knowledge versus American teachers in basic arithmetic, citing China's placement in the Trends in International Mathematics and Science Study (TIMMS) uppermost performance tier and the United States' placement in the middle tier.

One of the factors contributing to math anxiety may be the disconnection between the presentation of math in classrooms and the practical uses of math (Zaslavsky, 1996). Math in the educational setting is often presented as a theoretical and academic subject that does not have practical relevance for the students. The typical teaching process that

begins in elementary school presents the underlying principles of math and expects students to solve problems and produce a correct answer.

In contrast to the average math course, in real life knowledge is transitory; as a body of information evolves so does the knowledge needed to use it. Surveys of American employers from manufacturing and information technology indicate that for employees to be successful in the workplace, the most important attributes are problem solving, cooperation, flexibility, and persistence (Boaler, 2008). There is little indication of the knowledge of algebra rules or trigonometry dexterity the average employee must have to achieve success in the workplace.

Burns (1998) also argued that math anxiety or phobia develops from the rigid instructional approaches used in early math classes. The approach is often didactic and focuses on learning specific processes that students find irrelevant to their lives. The emphasis in early instruction on finding a correct answer does not lead to practical uses of math outside the classroom because many math applications require numerical approximation, decisions based on a range of possible correct answers. In addition, the use of pen-and-paper calculations in the classroom may discourage children from developing the skills necessary for making mental calculations, which are involved with many practical applications of math. This assessment of the classroom contribution to math anxiety is similar to that of Godbey (1997) who also indicated that teachers can create unnecessary psychological pressure to avoid the negative consequence of failure to produce correct answers on tests, and this added pressure in turn causes higher anxiety levels.

Strategies to Reduce Math Anxiety

Biggs and Preis (2001) recommended the use of stress management techniques and positive thinking as initial steps to reduce math anxiety. In addition, successfully solving math problems perceived as easy can break the cycle of math anxiety by providing a positive experience. This approach, however, places the burden for reduction of math anxiety on the student.

In contrast to Briggs and Preis (2001), the majority of the literature offers suggestions for teachers to reduce math anxiety. Rossman (2006) recommended that teachers take proactive measures to show the usefulness of math outside the classroom and to establish short-term goals that students can achieve, which breaks the cycle of poor performance and the initial stages of math anxiety. The emphasis on establishing relevance and usefulness of math in students' lives outside the classroom was also noted by Zaslavsky (1996) as an important technique for reducing math anxiety.

Stolp (2005) points out that introducing each new topic with a real world problem, whose context brings the mathematics to the students' world, rather than dragging the student into an abstract, imaginary world of mathematics is a more valid approach since the rationale for developing the concept is built into the lesson. Imagine a mathematics classroom where the students are not wondering, "Why do we need to know this?" This natural cognitive process of developing a useful strategy for a specific case and then validating it with an appropriate generalization establishes and reinforces the mental connections which promote deeper understanding. However, the contemporary math curriculum usually presents a new topic as an abstract generalization, whose application in a real world context comes later, if ever. Stolp (2005) advocates against this didactic

tradition, advising teachers to design solutions *with* students instead of *for* students, and upon arrival at the solution, taking explicit time to examine the path taken to it. This approach calls for students to individually inspect previous knowledge, construct personal and meaningful connections, and consistently evaluate and re-evaluate what has been learned. The idea is that students will be less likely to feel anxiety if they feel they are charting their own course through the world of mathematics.

Godbey (1997) suggested that teachers should be aware of the level of abstraction they present in math instruction based on the perceptions and cognitive developmental stages of students. In addition, teachers should attempt to communicate enthusiasm for the subject. Cavanaugh (2007) also indicated that a positive attitude of teachers towards students' difficulty with grasping math concepts is a critical factor for overcoming math anxiety. Scarpello (2007) also recommended that teachers use effective instructional practices to reduce math anxiety, but did not discuss specific practices that may be considered effective. One study found a significant reduction in anxiety levels of college algebra students during testing simply by playing soft music in the background (Haynes, 2003).

Rossman (2006) sums several researchers' findings and notes three areas that cause great anxiety in many students. These areas are imposed authority, public exposure, and timed deadlines. She indicates teachers can lessen the effects of math anxiety by ensuring instructions are clearly stated, avoiding situations that focus on students' misunderstandings, and removing unnecessary time constraints. Stolp (2005) suggests that, whenever possible, questions should be met with another question,

modifying the teacher's role from all-knowing transferor of knowledge to collaborator and colleague.

Woodard (2004) recommended the use of math tests that include justification of the processes involved in arriving at an answer to allow teachers to give partial credit for a correct understanding of the process even if the result is incorrect. He points out the assessment process for math should be more flexible and include the use of oral questioning and computing devices to accommodate students with different learning styles. Zaslavsky (1996) also indicated that the use of math assessments with no right or wrong answer is beneficial for reducing math anxiety because it reduces pressure on students to obtain the correct answer, allowing the student more opportunity to think freely about a situation and explore alternative solutions.

In contrast to Woodard (2004) and Zaslavsky (1996) who advocated altering the math assessment procedure, Cavanaugh (2007) suggests that math teachers should assist students with developing skills to overcome their anxiety in testing situations. This perspective is based on the assumption that regardless of the assessment approach used by an individual teacher or in a school system, many students will eventually have to take a traditional timed multiple-choice math test. To prepare students, teachers should practice taking short versions of this type of tests with students followed by extensive discussion of the processes necessary to obtain the answer. This instructional approach, however, is not widely advocated in the literature.

Tobias (1993) suggested that a specialized course or clinic is necessary to assist students overcome severe math anxiety issues. The purpose of the clinic is to provide students with thinking skills. The approach asks students to solve a math problem,

followed by extensive peer conversations about their thoughts and emotions during the problem-solving process. The approach is also intended to encourage students to be creative in their approaches to solving math problems. This type of intervention to overcome math anxiety is suggested to be more useful among older students.

Chapter 3: Research from the Classroom

I teach mostly required math courses and remedial classes in a large district that serves slightly less than five thousand students. My high school is designated low income, and the average math class has approximately thirty students. We utilize the block schedule, so the school day has four periods of eighty five minutes each. The school has a strong Advanced Placement program which includes higher level math courses such as Calculus and Statistics. Each year there are usually two calculus sections and one or two statistics sections as well as two or three remedial sections of basic algebra and five or six sections of required algebra. Here are some classroom strategies and methods I have found to be effective with anxious students.

A typical class period begins with my passing back graded homework and taking questions on the previous days' assignment. I believe every question should be answered if possible. Sometimes the answer is simply carefully reading the problem aloud and asking the class for input without writing anything on the board. I feel this strategy addresses the helplessness math anxious students feel. I am aware this practice is a double edged sword, as I reassure students to "Try, try, try, and even if you do not get the correct answer, I will show you how to do it tomorrow anyway; so do not get worked up over it", however many students give a problem a cursory glance and skip it only to copy it down later with no involvement or benefit. I feel the advantage of this practice outweighs this potential danger as I have found a motivated, but struggling student reaps huge benefits from working on the idea on their own with the reassurance that they can observe and learn how to do it later in spite of their trouble.

This practice at dealing with and overcoming frustration is another helpful way to stave off math anxiety. Seeing the problem worked the next day, students understand exactly what I am talking about as I explain it and are invested in the outcome. Even if they exclaim they would never have thought of that particular strategy, I find that thereafter many do. Affirming and reaffirming the process of making and fixing errors as an avenue for learning reassures students who become anxious at their mistakes.

Once homework has been passed to the in box, we begin the new lesson for the day. I require and grade notes in the lower level courses since many teenagers refuse to take notes or pay attention unless they get something for it. I work hard to write lessons that begin with previous knowledge. The difficulty here is that in a lower level class, deciding what previous knowledge I can reasonably expect them to have can be tricky. Starting with a simple fundamental concept and expanding it to include the new material seems to make the most sense with my students. I have found that providing deliberate pauses for students to write everything down, and after I have raised a question, keeps students engaged. At first this practice feels uncomfortable and awkward but truly most of the class will be thinking about the question or will finish writing and look up expectantly if I wait ten or fifteen seconds. (This feels like a *long* time when you are alone at the front of the room!)

This waiting strategy is also enormously effective when helping students one-on-one. Many students are extremely uncomfortable or frustrated at first, when they realize I will not tell them the answer. The math phobes especially become uptight when they are trying to do mental arithmetic with me in close proximity. I put on the patient hat and wait for them to get it. Even if I get up and get a calculator for them I mask all

impatience, reassure them with a smile or a word, and wait. This expectation that they can and must find the answers themselves is something many in the lower levels have not experienced. It is the beginning of empowerment for students. They must not feel helpless if possible. I try to keep the amount of text in the notes to a minimum, focusing on short sentences that describe the context and provide a few examples for their notebooks. The notes mirror the text when possible so students who do actually read and use the book will not find a different approach to complicate the issue. Then we look at the practice problems in the text and move to the assignment. I try to make sure to emphasize the work to show, demonstrating and verbalizing the thought process and steps necessary, over and over again. I explain that their own mental dialogue must be practiced as well as what they write on their paper. I require students to show work for a few reasons: first and foremost for students' organization of ideas in a visual format, secondly the repetition and practice that makes things more obvious and easier for students to predict, and finally to discourage copying the answers from the back of the book. Most students will buy the last reason even if they pooh-pooh the others.

Once we begin the day's assignment I usually work the first few problems with the class and assign the odds so they may check their work. During this work time I encourage students to work together as I move around the classroom assisting groups of students. Many students choose a spot on the floor with their friends to work. This can be difficult in the high school classroom as students tend to visit instead of doing their assignment, but I smile and push them to stay focused and use their class time wisely. I am persistent and for the most part, students find it easier to do the math than have me constantly asking them what they are doing and what problem they are on.

I find this group strategy effective for a few reasons. For one, students who struggle find that others struggle as well, yet they overcome their difficulties together. Many anxious students become frustrated and frozen trying to broach algebra alone at home. The group strategy thus discourages the isolation many math anxious students feel. For another, the more relaxed atmosphere allows me to sit next to a student on the floor and speak conversationally with them about their problem, minimizing my authoritative role and enhancing my role as collaborator.

An unconventional strategy I learned from a colleague is to write upside down, so when I sit backwards at a desk, facing a student, I can talk about what I'm doing and write it right-side-up for them on their page while they watch so the exchange is smoother. This helps move things along. Often I ask them what to do and dictate their work so we are not erasing and disrupting the process. This allows those anxious students to observe correct processes that they are directing in a non-threatening way. I feel this one-on-one collaboration is the most effective for helping anxious students. Most important here is to not convey frustration or impatience with them. These students are hypersensitive to these emotions and pick them up immediately with ruinous consequences.

For assignments, I do not grade individual problems, but insist students must be responsible for this on their own. I am amazed at how many students insist they don't want to 'waste' time checking the answer. In the first week or so of class, I find that day's assignment's answer page, and move around the room putting a post-it note on it for each student to facilitate answer checking and hopefully, autonomy.

I have found regular quizzes, either every couple of days or weekly, helps motivate students to keep abreast of the material. It is also easier to recover grade-wise from failing a small quiz than it is to recover from failing a large test. Math anxious students often stress obsessively over tests. I try to use the assessments provided by the publisher. My reasoning for this is that I expect them to read the text, learn from the text, and work problems from the text, so it makes sense that the assessment reflect and be presented the same as the work they are doing from the text in class. The book we currently use has quizzes in it that are nearly identical to the actual quizzes in problem difficulty and type so I assign these the night before as preparation, and answer questions on these practice quizzes in class before the actual quiz. I feel that if tests are what make students nervous, then they must be encouraged to prepare for the exact material they will be expected to do, and I communicate this. I also openly categorize the types of problems and what the directions mean with the class to help ensure instructions are explicit.

Insufficient preparation is a common cause of poor performance in the math classroom. In the lower level classes, much time is spent preparing for assessment. Students at this level do not have the academic maturity or discipline to prepare themselves (hence the reason they are relegated to lower level classes!) so I clearly teach them how. If I am using a text that does not have these built in quizzes, I write them using the assignments as a guide and inform the students their assessments come directly from the homework so they must make sure they are properly utilizing the question and answer aspect at the beginning of the class. For upper level classes, I encourage anxious students to read text examples instead of working problems the night before the test so

they can observe and assimilate problems correctly without the frustration of failure to cast doubt on their ability at a crucial time.

As for larger unit tests, I assign the text review and try to teach students to decide for themselves what material they are struggling with so they can re-read their notes or the associated section or find help in some other way. Always I emphasize their performance is in their hands; they have the power to be successful. The tests themselves will have no surprises or trick questions, they will have seen and had the opportunity to ask and clarify any issue beforehand. I feel strongly that as an 'expert' in what I am teaching, I can determine students' grasp of a concept with reasonable problems that have reasonable answers. I am not advocating 'easy' or watered down assessments. I am promoting reasonable problems of a kind students have worked already. I feel the tricky problems are interesting and important; their place is the assignment or group activity where students can think about them without the fear and subsequent anxiety of failing a test.

As a result of student anxiety and insecurity regarding assessment, in the remedial classes I let students use their notes on tests so if they 'draw a blank' they can find the information they need. In the required classes I distribute half sheets of colored copy paper the day before the test so they can prepare study sheets for themselves to use on the test. I do not allow these aids in the AP statistics class, although each student has the AP Statistics exam's formula sheet and may use it for all assessments. I feel this approach directly addresses the feeling of helplessness many math-anxious students experience. In the lower classes students should have examples in their notes. When they become stuck, I help find the topic in their notes and point out the example. I feel this approach,

supporting student performance and pushing them to be successful on their own is the single most important aspect of easing math anxiety. If together we can reduce the amount of failure we can avoid the first aspect of the math avoidance cycle: the negative reaction to math experiences.

I used to allow students to re-work or improve their test scores but I prefer to focus on attaining the confidence that results from proper preparation. In this way, they must learn to refocus their effort and move forward instead of dwelling on failure. In my experience (and I share this, too), the only students who fail in the end are those who give up. No single test will cost them credit for the class, and I feel very strongly that it is my responsibility to provide every student the *opportunity* for success, but that ultimately it is up to them to claim it. This is another crucial shift that I feel leads to overcoming math anxiety: students must feel their success is a result of their effort and hard work and not a result of good fortune.

Another aspect is the less than formal atmosphere in my room. I consciously try to smile and express that I am happy teaching, I like the class, and I enjoy my students. I listen to their stories and tell my own. I admit to them that as a math student myself I have flunked more tests than they can imagine, and try to identify with their struggles and insecurities with stories of my own frustrations as a math student. This revelation to students of my own inadequacies and tribulations serves to reassure math anxious students that making mistakes and feeling frustrated is common in math world. When I make mistakes on the board I fix them and make some self deprecating comment. I believe it helps students with their own mental dialogue; they seem to feel I shouldn't say things like "Wow, I'm so lame, look what I did there!" (and many students communicate

this), so perhaps they will forgive themselves the same blunders. I share these experiences in order to reveal what more students have said to me than any other single thing:

"*We do well in your class because we like you."*

As a practice I do not go about trying to make students like me, as this would be a futile and frustrating proposition in any situation. Instead *I try to like my students*. This can be difficult and sometimes impossible, but genuine warmth is hard to resist. The most hardened student can have their walls melted away with kindness. Sometimes this means setting the math aside and instead listening to their other difficulties. I believe mathematics achievement fulfills a higher psychological need for self-actualization. Students who are hungry, unsafe, or struggling with some other psychological or family issue are ill-equipped to be successful in mathematics. I also believe that the skills needed to thrive in the mathematics classroom are generally already present. What I feel is needed is motivation to put the pieces together and use them effectively. As teachers, we need to foster perseverance and enthusiasm more than any skill, as these pave the way for success in all things.

Chapter 4: Discussion of Research

The research has covered several aspects of math anxiety, including the extent, cognitive effects, contributing factors, and the role teachers play in the cycle of math avoidance that ultimately causes math anxiety. In reviewing the literature, several themes stand out.

First and foremost is that math anxiety is real. Whether it is pathology or a social construct is unclear. What is validated by the research of Godbey (1997) and Ashcraft and Krause (2007) is that a student in the throes of math anxiety is literally working with reduced cognitive capabilities, so when a student says they don't have any idea what to do, it may actually be the case. At the least, research from Burns (1998) and Johnson (2003) indicates teachers can expect roughly one quarter of their students to exhibit symptoms of math anxiety.

Students at risk for developing math anxiety tend to practice avoidance as a coping mechanism, as described by findings of Godbey (1997), and Preis and Biggs (2001). As frustrating as it is for students to fail to be prepared, this phenomenon is common and can be identified and addressed if the teacher understands the vicious cycle of math avoidance that results in math anxiety.

Multiple researchers such as Godbey (1997), Woodard (2004), and Johnson (2003) agree that many factors contribute to math anxiety. These can be loosely grouped into internal and external factors, as determined by the research of Woodard (2004). The role of the teacher is the most convenient and efficient factor that can be modified, as parental opinion and myths surrounding mathematical prowess are more difficult, if not impossible to control. Internal factors such as those described by Woodard (2004) that

can be identified and illuminated in the classroom are predispositions for frustration and low self esteem. The research of Scarpello (2007) indicates math anxiety afflicts females and males at approximately the same regularity in the high school classroom, with females affected at a slightly higher relative frequency.

Zaslavsky (1996) advises that teachers may inadvertently suggest to students that they are not capable of performing grade level mathematics, and points out that attitudes towards struggling students that communicate frustration and impatience reinforce to students that they cannot be helped. The research of Cavanaugh (2007) indicates positive feedback from the teacher regarding mistakes is crucial in overcoming math anxiety. Differentiated expectations fuel this negative self-concept; performance expectations must be the same for all students, even if some require more support than others, as suggested by the work of Zaslavsky (1996).

The work of Rossman (2006) advocates rote memorization and drill contribute to math anxiety. When a student is able to complete homework effectively but is unable to perform the same tasks on assessments, they are left doubting their ability and the depth of their understanding. Stolp (2005) maintains mathematics must be perceived as a conceptual tool and not as an abstract theoretical concept. According to his research, students must participate in the construction of the conceptual framework for them to effectively assimilate new information. Connections must be discovered rather than memorized for students to be able to apply mathematics in new contexts.

Zaslavsky (1996) and Woodard (2004) indicate assessment that focuses exclusively on correct answers also contributes to math anxiety. The correct answer should be a component of the evaluation but not the only determination of student

knowledge. Woodard (2004) suggests assessments should be designed to assess the processes necessary to arrive at the answer as well. Burns (1998) suggests that when possible, unnecessary time constraints should be removed as this, too, creates stress that sips cognitive functioning. Deliberate activities designed for success can enhance student confidence and break the cycle of math avoidance, according to Rossman (2006). Establishing short term goals helps to facilitate student achievement which then postures them psychologically toward attainment of long term goals.

Students can be taught common stress management techniques such as visualizations and deep breathing to help control anxiety levels in the math classroom, as suggested by Biggs and Preis (2001). Haynes (2003) found that soft background music significantly reduced anxiety levels during testing. Godbey (1997) maintains teacher enthusiasm and encouragement are integral to maintaining an effective environment that reduces the likelihood of the development of math anxiety. Multiple choice tests, such as the high stakes tests most students will eventually have to face, can be practiced and strategies learned to foster confidence in characteristically stressful testing situations, suggests Cavanaugh (2007). Tobias (1993) maintains that identification and discussion of the emotional processes students encounter as they struggle with math can help students develop metacognitive skills to help themselves overcome math anxiety.

In my classroom, I have found that treating every question as a legitimate request for assistance helps reassure students that their struggles are valid. Utilizing a question and answer period each day regarding assignments helps students who struggle to address their own issues. Having to face frustration and work through it safely with support helps students who suffer from math anxiety. This also implies careful discretion regarding

expression of emotions of frustration and impatience on the part of the teacher who must answer the same question over and over. Employing deliberate 'wait time' allows students to digest and assimilate information during lessons and during work time. Presenting a model for self-talk helps students develop their own internal strategies for dealing with mathematical situations. Providing time in class to work on assignments addresses the needs of students who feel helpless and isolated when they work on math alone.

Smaller, more frequent quizzes help students stay motivated to stay on top of the material and provide practice for larger assessments. Proper emphasis on test preparation can shift the power of a student to succeed from good luck to good work. Some anxious students benefit from being able to use their notes or a self-constructed study sheet on tests. In this case they are able to locate the information needed to be successful on their own. Tests themselves should consist of reasonable problems of a type students have already worked and had the opportunity to ask for clarification on.

Another useful tactic is modifying the absolute authority role of the teacher role to one of collaborator. Fundamentally, a student's opinion of the teacher has everything to do with how they respond to and deal with the inevitable frustration and failure that is experienced in nearly every math classroom. They are more easily motivated to be resilient if they feel the teacher cares and is doing their best to ensure their success.

Chapter 5: Conclusion

This research has verified for me that math anxiety exists and has an identified cycle. As teachers, we fall into the first category of external variables that relate to math anxiety. My own actions are the easiest and most obvious adjustments I can make to ease or avoid math anxiety altogether. I am relieved to find that in many cases students are not trying to test my patience by insisting they can not perform the math but that there is a real cognitive occurrence that is causing this disruption in the learning process.

Estimates of the relative frequency of math anxiety range from roughly one fourth to two thirds of the population. In my experience both of these figures are accurate, from the average required math class to the remedial course, respectively. I have struggled with meticulous preparations for assessment only to have students insist they can't do it or that they simply do not know what to do. Pointing out to them that even though in supporting them I do not give answers or directions, merely asking questions to nudge them towards the solution path while they themselves find the way, they often maintain they can not do the math without me. These kinds of observations are what led me to research this topic.

In performing the research, I also discovered some new tactics that I intend to use in my classroom to assist students with math anxiety. One is greater emphasis on cooperative learning groups. With curriculum rigidly imposed I have encountered difficulty in allocating time for this but evidence abounds which supports it's utility in the math classroom. One way I can implement this strategy is to assign the word problems the students seem to avoid and have them work them together. I have made weak attempts at this before but sadly I did not follow through with the exercise until students

learned to be successful. I found that this was more effective after students had some practice with the mathematics beforehand. I have a new resolve to utilize this avenue as a result of my research findings.

Another tool I discovered is the Mathematics Anxiety Rating Scale or MARS. This is a ninety eight item questionnaire designed to assess a students' level of math anxiety. Several shortened versions are included in the appendix of this paper. I feel that using these tools to broach the subject of math anxiety will be useful in identification of the issue for my students. In my experience, math phobes do not share their fears but usually mask them with various evasive behaviors. I intend to discover if discussing and addressing math anxiety will ease the isolation so many anxious students feel and help more students overcome this burden.

The structure of the texts that my department uses makes the process of introducing new ideas with a problem as suggested by several researchers more difficult. However, I feel that writing and introducing one or two new problems each year for this purpose is a reasonable task that could be accomplished and which has been shown to be successful in bridging mathematics to real life so I intend to implement this aspect over time.

The publisher's tests and quizzes I am so fond of using usually do not include enough space for students to show work. I have made it a practice to have students show their work on separate paper but this is very time consuming to grade. I feel I should write assessments that include steps so I can more easily grade students' work and award partial credit for the process as this is difficult when there are sixty to seventy tests to grade.

Another piece I intend to develop and use is language for helping students reduce their own stress levels. I will make it a point to research appropriate stress reducing techniques that I can apply in my class when students appear to be in the throes of anxiety.

The research conducted for the purpose of this paper has outlined several strategies for helping math anxious students, as summarized in the following list:

1. Math anxiety affects twenty five to sixty seven percent of the population. Expect to have students who suffer from it.
2. Try to communicate patience and empathy for students' struggles with anxiety.
3. As the teacher, minimize your role as dictator and authoritarian. Emphasize your role as collaborator and colleague.
4. Make lectures as succinct as possible. Provide sufficient wait time for students to assimilate new information.
5. Address every question if possible, with patience and enthusiasm.
6. Encourage students to work in groups. They will help each other overcome their difficulties.
7. Give frequent, smaller quizzes. It will help students assess their own understanding and offer an idea of what to expect on the larger tests.
8. Provide structured test preparation. Communicate to students they can succeed if they work hard even if they struggle.
9. Use assessment as a tool to measure the knowledge students gain from the exercises, not as a way for an elite handful of students to rise to the top.

10. Try to like your students. They will perform better and work harder if they feel you care about their success. Their opinion of you directly postures them for success or failure in your class.

I feel there is a need for more research on specific teacher practices that incite anxiety. It appears as though the phenomenon of math anxiety is well researched and documented yet many people veritably roll their eyes when I tell them my topic. How is it that so much time and energy has been invested in understanding this concept yet so few teachers know about it? I feel a course on this topic would benefit many of the math teachers I know, including myself. Any other disorder that affected a quarter of the population would be widely known and teaching staff would be well educated in identifying and helping students who suffered from it. Also, curriculum and specific instructional practices could be developed and their effectiveness documented with the math phobe in mind that would serve to lessen or sidestep the effects of math anxiety.

In conclusion, the research has validated what I have suspected for some time: math anxiety is not a reaction to mathematics itself but an outcome of the mathematics classroom. As teachers we are in a unique position to prevent the development of math anxiety. It appears from the research that teacher changes in attitude and support play a key role in the reduction of math anxiety. There was a time when I felt resentful of those students who failed and, like many others, insisted this failure was due to laziness. I feel these students perceive this resentment and it fuels their anxiety. It occurs to me that the conventional way of teaching math, with its "Survival of the Fittest" mentality and didactic methods of instruction produces teachers like myself whose comfort zone was exactly the same. I feel that in many cases, these students are "lazy", per se, because they

are not being properly motivated or encouraged to succeed. They embrace their failure and their role as such the same as their teachers do. With intent and a desire to truly help students, I feel we can reduce this widespread phenomenon with sensible changes in attitude and practice.

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Appendix A: Four Abbreviated Versions of the MARS for Math Test Anxiety

Read each statement and circle the ones that describe situations that make you feel anxious or uncomfortable.

1. Studying for a math test
2. Take math section of college entrance exam
3. Taking an exam (quiz) in a math course
4. Taking an exam (final) in a math course
5. Picking up a math textbook to begin working on a homework assignment
6. Being given homework assignments of many difficult problems that are due the next class meeting
7. Thinking about an upcoming math test 1 week before
8. Thinking about an upcoming math test 1 day before
9. Thinking about an upcoming math test 1 hour before
10. Realizing you have to take a certain number of math classes to fulfill requirements
11. Picking up a math textbook to begin a difficult reading assignment
12. Receiving your final math grade in the mail
13. Opening a math book and seeing a page full of problems
14. Getting ready to study for a math test
15. Being given a "pop" quiz in a math class

Adapted from Alexander, L. & Martray, C. (1989). The development of an abbreviated version of the mathematics anxiety rating scale. *Measurement and Evaluation in Counseling and Development*, 22(3), 143-150.

Negative Attitude Toward Mathematics (NATM) Subscale	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
Taking a math test is a frightening experience for me	1	2	3	4	5
I am nervous about mathematics	1	2	3	4	5
I make low scores on most of my math tests	1	2	3	4	5
I feel a lot of pressure taking a math course	1	2	3	4	5
My mind seems to go blank during math tests	1	2	3	4	5
Mathematics is one of my worst subjects	1	2	3	4	5
I am afraid to submit my math tests or assignments	1	2	3	4	5
Math formulas are difficult for me to remember during tests	1	2	3	4	5
It is difficult for me to grasp math concepts	1	2	3	4	5
I have a special dislike for mathematics	1	2	3	4	5
I make low scores on my math assignments	1	2	3	4	5
It takes me a while to solve a math problem	1	2	3	4	5
I feel a lot of stress taking a math test	1	2	3	4	5
It is difficult for me to understand math instructions	1	2	3	4	5
I don't want my math tests or assignments to be evaluated	1	2	3	4	5
I avoid mathematics courses	1	2	3	4	5
I depend on my tutors for help in math	1	2	3	4	5
I am no good at solving math problems	1	2	3	4	5
Mathematics is a boring subject	1	2	3	4	5
I generally cram a lot of information before a math test	1	2	3	4	5
I blame myself for my poor performance in mathematics	1	2	3	4	5
I do my math homework alone	1	2	3	4	5

Positive Attitude Toward Mathematics (PATM) Subscale	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
Mathematics is one of my favorite subjects	1	2	3	4	5
I am fond of mathematics logic	1	2	3	4	5
Mathematics is an exciting course	1	2	3	4	5
I like answering math questions in class	1	2	3	4	5
Learning and understanding math can be fun	1	2	3	4	5
I enjoy showing others how to solve math problems	1	2	3	4	5
I always do well on math exams	1	2	3	4	5
It is a joy to transform word problems into math expressions	1	2	3	4	5
I feel confident in my ability to solve math problems	1	2	3	4	5
I enjoy mathematics	1	2	3	4	5
I volunteer myself to solve math problems on the board	1	2	3	4	5
Most of my courses are math related	1	2	3	4	5
I like seeing the steps I used to arrive at my solution	1	2	3	4	5
I learn math by solving problems	1	2	3	4	5
Doing workbook exercises help improve my math scores	1	2	3	4	5
Mathematics comes easy for me	1	2	3	4	5
Mathematics is a great challenge for me	1	2	3	4	5
My peers seem to understand me better than the teacher	1	2	3	4	5

T. Nelson Ikegulu, Research Associate, Department of Mathematics & Computer Science, Grambling State University, Grambling, LA, Dec 15, 1998

Dutton's Attitude Scale

Directions: Place a check in either the 'agree' or 'disagree' box, depending upon which expresses your true feelings.

	Agree	Disagree
1. I think about mathematics problems outside of school and like to work them out.	☐	☐
2. I don't feel sure of myself in mathematics.	☐	☐
3. I enjoy seeing how rapidly and accurately I can work math problems.	☐	☐
4. I like math, but I like other subjects just as well.	☐	☐
5. I like math because it is practical.	☐	☐
6. I don't think math is fun, but I always want to do well in it.	☐	☐
7. I am not enthusiastic about math, but I have no real dislike for it either.	☐	☐
8. Mathematics is as important as any other subject.	☐	☐
9. Math is something you have to do even though it is not enjoyable.	☐	☐
10. Sometimes I enjoy the challenge presented by a math problem.	☐	☐
11. I have always been afraid of math.	☐	☐
12. I would like to spend more time in school working math.	☐	☐
13. I detest math and avoid using it at all times.	☐	☐
14. I enjoy doing problems when I know how to work them out.	☐	☐
15. I avoid math because I am not very good with figures.	☐	☐
16. Math thrills me, and I like it better than any other subject.	☐	☐
17. I never get tired of working with numbers.	☐	☐
18. I am afraid of doing word problems.	☐	☐
19. Mathematics is very interesting.	☐	☐
20. I have never liked mathematics.	☐	☐
21. I think math is the most enjoyable subject I have ever taken.	☐	☐

Dutton's Scale

These are the multiplying factors for the Agree/Disagree Dutton's Scale.

1. 9.5
2. 3.7
3. 8.6
4. 5.6
5. 7.7
6. 4.6
7. 5.3
8. 5.9
9. 3.3
10. 7.0
11. 2.5
12. 9.0
13. 1.0
14. 6.7
15. 3.2
16. 10.5
17. 9.8
18. 2.0
19. 18.1
20. 1.5
21. 10.4

Retrieved August 10, 2010 from unknown online source.

Math Anxiety Scale

For each statement circle a number 1-5 which indicates whether you strongly agree (5), agree (4), no opinion (3), disagree (2) or strongly disagree (1).

1. I usually have been at ease in math classes.	1	2	3	4	5
2. I see math as a subject I will rarely use.	1	2	3	4	5
3. I'm no good at math.	1	2	3	4	5
4. Generally, I have felt secure about attempting math.	1	2	3	4	5
5. I'll need mathematics for my future work.	1	2	3	4	5
6. I'd be happy to get good grades in mathematics.	1	2	3	4	5
7. I don't think that I could do advanced math.	1	2	3	4	5
8. It wouldn't bother me at all to take more math courses.	1	2	3	4	5
9. For some reason, even though I study, math seems unusually hard for me.	1	2	3	4	5
10. My mind goes blank and I am unable to think clearly when working in mathematics.	1	2	3	4	5
11. Knowing mathematics will help me earn a living.	1	2	3	4	5
12. Math has been my worst subject.	1	2	3	4	5
13. I think I could handle more difficult mathematics.	1	2	3	4	5
14. I'm not the type to do well in mathematics.	1	2	3	4	5
15. Math doesn't scare me at all.	1	2	3	4	5

Compute the mean for questions 1,4,5,6,8,11,and 15:_____

Compute the mean for questions 2,3,7,9,10,12,and 14:_____

Retrieved August 2010 from: http://www.unm.edu/~khaled/Math%20Anxiety%20Scale.doc

Appendix B: Math Myths

Do You Believe?
Courtesy of Ashley DuLac and Kathryn Brooks

Men are better in math than women?
Math requires logic, not intuition?
Mathematicians are smarter than most people?
Some people have a math mind, others don't?
Math is rigid?
Mathematicians do problems quickly, in their heads?
Mathematicians rarely make mistakes?
There are magic keys to doing math?
It's bad to count on your fingers?
Math is not creative?
Mathematicians are eccentric?
Math requires lots of memorization?
Most people don't have to know math for daily living?
In doing math, it's important to get the answer exactly right?
Math problems are done by working intensely until the problem is solved?
There is always one best way to do a math problem?
You must always know just how you got the answer?
Math is fun?

Overcoming Math Anxiety, Sheila Tobias

Appendix C: Math Anxiety Bill of Rights

Math Anxiety Bill of Rights, by Sandra L. Davis

I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else.
I have the right to ask whatever questions I have.
I have the right to need extra help.
I have the right to ask a teacher or a TA for help.
I have the right to say I don't understand.
I have the right not to understand.
I have the right to feel good about myself regardless of my abilities in math.
I have the right not to base my self-worth on my math skills.
I have the right to view myself as capable of learning math.
I have the right to evaluate my math instructors and how they teach.
I have the right to relax.
I have the right to be treated as a competent adult.
I have the right to dislike math.
I have the right to define success in my own terms.

Overcoming Math Anxiety, Sheila Tobias