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A Comprehensive Study of Mathematics Anxiety

Connie E. Shannon
The College at Brockport, cessma@rit.edu

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Connie E. Shannon

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Connie E. Shannon

APPROVED BY:

Conrad Van Voorst — Advisor — 8/4/08 — Date

Director, Graduate Programs — 8/12/08 — Date

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Chapter One: Overview

Math anxiety is a phenomenon in which students suffer from an irrational fear of mathematics that affects their ability to learn, comprehend, practice, and perform mathematical problems and procedures. (Miller & Mitchell, 1994) This anxiety can cause an inability to think and/or process new information. Students are not born with math anxieties; they are victims to the system.

According to Hadfield and McNeil (1994) the causes of math anxiety can be divided into three areas: environmental, intellectual and personality factors. Environmental factors include negative experiences in the classroom, parental pressure, insensitive teachers, math taught as a rigid set of rules and non-participatory classrooms. (Dossel, 1993) Intellectual factors include being taught with mismatched learning styles, student attitude and lack of persistence, self-doubt, lack of confidence in mathematical ability and lack of perceived usefulness of mathematics. (Cemen, 1987) Personality factors include reluctance to ask questions due to shyness, low self-esteem, and viewing mathematics as a male domain. (Cemen, 1987)

According to Tyson (2001) we are not wired for logical thinking. If we were, then mathematics would be the average person's easiest subject in school. In this alternate universe, math might not be taught at all, because its foundations and principles would be self-evident and even to slow-achieving students. However, in our world people had to invent the concepts of counting and build upon with the growing complexities of life and society.

Many math anxious students remember an extremely embarrassing moment in their math history that was the catalyst for their anxieties and dislike for the subject. The catalyst is most often an insensitive remark from a frustrated teacher. As the number of these experiences grows, the student is more likely to give up more quickly when faced with a challenging math problem. For example, Sarah was an elementary education student who was convinced she had the inability to complete word problems. However when asked to complete a very simple verbal word problem, "Mary is a 6 year old. She wants a pony for her tenth birthday. How long must Mary wait?" Sarah's fears prohibited her from actually hearing the problem in the first place let alone how simple it was. (Miller & Mitchell, 1994)

Math anxiety became an interest of mine when my son had his first negative mathematics experience in the third grade. His teacher believed the best way for students to learn the multiplication table was to create a timed competition. My son did not do well with this type of assessment. The stress of being timed caused him unnecessary math anxiety.

During my student teaching experiences with middle and high school students I have seen math anxieties at work. It was intriguing to observe students dealing with anxiety. It was also enjoyable to help them work through their anxieties. I was glad to see that some students took matters into their own hands and sought out help for their difficulties. One high school student in particular spoke to me about how math has been a problem subject for him since middle school. He described his fears of failure and embarrassment and how those fears have affected his success in math. The literature review I have completed has confirmed his behavior as math anxiety.

According to Austin & Wadlington (1992) self-esteem and self-concept play a part in math anxiety as well. Many students believe that their grades are a representation of themselves. If these grades suffer in any way, it is an indication that they are not perfect and their peers will witness it. They hold themselves to ridiculously high standards causing themselves undue stress and anxiety. Conversely, some students are teased because of their good grades. Some students actually fear doing well because they do not want to be picked on by their friends. Sometimes these students will camouflage their abilities in order to gain acceptance from their friends. I did not want my son's self-esteem or self-concept to be affected by this type of assessment.

The study I conducted was an anonymous questionnaire that included questions directed at elementary, middle and high school teachers regarding teachers' anxieties, students' anxieties and what teaching techniques and instructional strategies were used to reduce these anxieties. The questionnaires were mailed to the participants and were returned in a self-addressed stamped envelope. There were 15 teachers included in the survey but only ten of those choose to participate.

The results of the study were very similar to the literature I have reviewed for this project. The teachers commented on anxieties based on a lack of experience with a particular topic of math, a lack of preparation for a lesson, and the fear that they were not connecting the math to the students' prior knowledge. The majority of the teachers stated that they reviewed extra problems and made sure they were prepared for the class to help lessen their anxieties. The teachers were able to recognize math anxieties in their students as well. They stated that some of the symptoms were frustration, avoidance, disengaged, and low homework and test scores. They suggested that working one-on-one

with the students, increasing the number of hands-on activities, and connecting the math to real world situations.

The current trend and the future direction for the study of math anxiety is to discover its origin, what causes it, who does it affect the most, and what are the best intervention programs available to reduce it. The more reasons researchers can find for the creating on math anxiety the more information they will have to create programs that will help to reduce it. Future studies regarding who is affected will also help in the creation if interventions. Finally, testing the intervention programs to see which ones work the best and have the longest positive affect on the students, pre-service teachers and active teachers will be beneficial to all who live with mathematics anxieties.

Chapter One: Rationale

Mathematics anxiety has been an interest for me since my student teaching experiences. Not only did I see students in middle and high school with math anxiety but I also saw my son experience math anxiety in the third grade. The children were learning their multiplication tables. The teacher felt it would encourage the students to learn if there was some competition. They were given small, twenty question quizzes that were timed. The first quiz covered the one's (1 x 1, 1 x 2, etc.), the second covered the two's and so forth. Each time the student took a quiz and failed to complete all twenty questions in a one minute period, a grade was given based on the number of completed questions. Then the student had to take the same quiz over and over until they got all twenty questions correct in the one minute time frame. Those grades were then averaged together for a final grade for that particular part of the multiplication table. She titled this form of assessment "Mad Minutes".

The anxiety was created because these tests were given in front of the other students and progress was posted on the wall for the other students to see. My son has a mild form of Tourettes Syndrome. Tourettes is a neurological disorder that involuntarily causes a person to twitch or make sounds. Attention Deficit Disorder (ADD) is a part of Tourettes and also affects my son. ADD is a disorder that causes a person to become easily distracted. This in turn hinders the person's ability to complete tasks without redirection from another. My son is easily distracted and had a very difficult time with these timed tests. He had to take each test 3 to 5 times while his friends were finishing each test after 1 or 2 times. He friends were receiving gold stars for each test on the chart

in the classroom at a faster rate than he was and it was embarrassing to him to see how he was lagging behind. I tried to explain the circumstances to the teacher but she told me that she has been "doing it this way for years" and she had no intention on stopping.

My son does not normally have mathematics anxieties. He is a very smart boy and has always received straight A's in his math classes. This was the only time he experienced anxiety and it was due to the teaching style of the teacher. I was intrigued with this topic from then on. I wanted to know what other causes existed for math anxiety and how it could be address or avoided all together.

My goal was to distribute a questionnaire to elementary, middle and high school teachers to see if these teachers carry their own anxieties and what, if anything, did they do about it. I was interested to see if they feel there was something lacking in their education that could have caused an anxiety. I would like to know if math anxiety is diagnosed and/or addressed. I would also like to know what steps, if any, are taken to help students work with and overcome their math anxieties.

Chapter One: Connections to State Standards

The National Council of Teachers of Mathematics (NCTM) advises "letting students have some input into their own evaluations and emphasizing the importance of original, quality thinking rather than rote manipulation of formulas," researchers in the field of Learning Disabilities concur, suggesting that self-talk is helpful in developing positive self-evaluation. Self-talk is defined as a "guiding self-dialog engaged in an individual while completing a task" (Kamana & Wong 1993)

The NCTM (1989) Standards call for a focus on the process, rather than on the product of mathematics, so that students can become better, persistent problem-solvers in their everyday lives. The NCTM also states that students need to value math and be able to manipulate, see, and communicate mathematics, both orally and in writing.

The Process Strands of the New York Sate Standards include Problem Solving, Reasoning and Proof, Communication, Connections, and Representation. These strands highlight ways of acquiring and using content knowledge. These process strands help to give meaning to mathematics and help students to see mathematics as a discipline rather than a set of isolated skills. Student engagement in mathematical content is accomplished through these process strands. Students will gain a better understanding of mathematics and have longer retention of mathematical knowledge as they solve problems, reason mathematically, prove mathematical relationships, participate in mathematical discourse, make mathematical connections, and model and represent mathematical ideas in a variety of ways. (NYS Standards, 2005) The focus of these strands by teachers will greatly reduce to possibility of their students developing math anxiety. If the students are able to

make connections in mathematics and communicate using mathematical vocabulary they will have a better chance of avoiding math anxiety altogether.

Chapter One: Research

The topic of Mathematics Anxiety has been studied in depth for the past 30 years. While gathering research for this project several topics regarding math anxiety continually emerged. The four main topics include causes, racial and gender differences, evaluating pre-service teachers, and solutions to the math anxiety issue.

There are several causes for math anxiety. Teachers, parents, test anxiety and working memory capacity are the most significant. Teachers have an extremely important role when it comes to creating a safe and positive environment for students to learn math. It is their responsibility to teach with the understanding that thy can be the cause of math anxieties in their students. They are capable of bringing their own anxieties into the classroom and have the ability to allow their own frustrations affect the students' attitudes toward math. Parents are also important role models when it comes to math. The parents' attitudes and perceptions are observed and replicated by the students. If parents have positive attitudes toward math then so will the student. Test anxiety has a direct effect on math anxiety. If a study has test anxiety it will ultimately affect his test scores. These low test scores will then cause the student to build negative attitudes and perceptions toward math which will lead to math anxiety. Finally, working memory capacity has been studied as a possible cause because it can be affected by unnecessary worry and negative thoughts.

The second section of the research is based on racial and gender differences. Many researchers find it necessary to know the differences and why they exist. They also

want to know the best way to deal with these differences. For example, would single sex math classes be beneficial to the success of the female students.

A large part of the research had focused on pre-service teachers. Pre-service teachers are students studying to become teachers. The majority of pre-service teachers included in these studies were planning to become elementary teachers. Many of the researchers believe that math anxiety begins in elementary school from teachers who are math anxious themselves, do not have enough math education and do not know how to connect the concepts of math. Studies have focused on the learning about the anxieties of pre-service teachers and what intervention programs may help to alleviate their anxieties. The goal of these researchers is to prevent the pre-service teachers from bringing their math anxieties into the classroom.

Finally, the last section of my research has to do with solutions to the math anxiety dilemma. Many studies have focused on gathering data regarding the origin of math anxieties and then use that information to create intervention courses and programs to help reduce or eliminate math anxiety in students as well as teachers. Several studies give detailed lists of how teachers themselves can prevent or reduce math anxieties in their students.

Chapter One: Current Trends and Future Projections

The majority of the studies I have encountered have focused on finding the reasons behind the existence of math anxiety. In an effort to direct those who wish to create interventions, these studies have covered topics such as working memory capacity, racial and gender differences, early negatives math experiences, and test anxiety. Other studies test different interventions to see what affect, if any, they have on students with math anxiety. The researchers seem to be narrowing down the best methods of reducing and eliminating math anxiety.

Future research on topics such as how cognitive and social factors affect attitudes toward math, how attitudes toward math develop and the stability of those attitudes over time, what variables exist that may help to explain the different levels of math anxiety, what interventions have the greatest success and which of those interventions have the longest lasting positive affect on students. Much of the research I have encountered has had a limited number of participants. Many times researchers have commented on how often students choose not to partake in the studies. Their guess is that those with the highest math anxieties have a tendency to avoid situations where they will be required to admit that fact. It is my belief based on the literature review and my own study that testing and intervention of mathematics anxiety should be required for all mathematics teachers from elementary school through college and into the profession careers of teachers.

Chapter Two: Causes:

Teachers & Parents

Teachers and parents consciously and unconsciously model behaviors that show their own anxieties about math. It is important to remember that a child's first exposure to mathematics by their elementary teachers greatly affects the child's future experiences with the subject. Ineffective teaching techniques are often responsible for anxieties. If a teacher always uses the same approach to teaching, gives the same work to all students, accepts only one way to solve a problem and follows the textbook page by page then many students will have increased anxieties.

Studies have shown that many elementary school teachers have negative math attitudes that were passed down from their own teachers as well as their parents. They bring with them negative math self-concepts based on inadequate math backgrounds and lack of math understanding. Some actually choose to be elementary school teachers because there is a minimal amount of math at that level. They are choosing to avoid math as much as possible. (Austin & Wadlington, 1992)

There are several math myths that teachers believe in. Austin & Wadlington (1992) gave The Mathematical Belief Survey Instrument (MBSI) to teachers to determine what their beliefs on the subject matter are. There are 13 questions and the teachers are asked to choose between 1 and 5 the level of their belief. It was shown that if an elementary teacher has negative beliefs of mathematics they often do not portray characteristics of effective math teachers. An in-service teacher stated that she believed a good memory was necessary for success in mathematics. She also stated that she was

told at an early age that she had a good memory for math which is why she was so successful herself.

Two thirds of the teachers surveyed agreed that some people have a math mind and some don't, with the high-anxiety pre-service group being the one who believed it the most. Several of these teachers claimed they did not acquire the needed skills in order to be confident in math and the problem escalated throughout their school years. (Austin & Wadlington, 1992)

Parents play a strong role in how well children do in school as well as how much anxiety they have. Parent's perceptions of their child's abilities and their own biases strongly relate to the child's beliefs and attitudes regarding mathematics. Entwisle and Alexander (1988) reported parental psychological support to be the most influential of all the variables they considered. They found that parents' self-reported math anxiety had a negative correlation with the test scores of their child. The less anxiety the parents' had the higher the child's test scores were.

Tucci & Engelhard (1991) conducted a study that looked to see if there were any significant interactive effects among gender achievement and parental support on attitudes toward math. The parental support test assessed the students views of their parents and if they enjoyed encounters with math, their interest and ability to assist student with math homework and if the parents encouraged the student to study and do well in math. The results of the study showed that parent behaviors were positively related to student attitudes towards math and had an inverse affect on their math anxiety.

Chapter Two: Causes:

Test Anxiety

Test anxiety stems from task irrelevant thoughts such as inadequacy, helplessness, and concern over loss of status. (Arkin, Kolditz & Kolditz, 1983) These researchers also reported a pattern in which those students with high levels of test anxiety are more likely to attribute failure to a lack of ability and to attribute success to behavioral characteristics such as effort. Leppin et al. (1987) suggested that a negative self concept about one's own resources may in turn lead to the development of anxiety. Benson et al. (1994) revealed that math self-concept has a strong positive influence or perceived self-efficacy in learning new mathematics.

Bandura (1986) defines perceived self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances." Those who form perceptions of themselves as inefficacious tend to give up easily, dwell on their perceived deficiencies, thus detracting their attention from the task at hand; suffer from anxiety and stress and attribute their successes to external factors. (Bandura, 1986)

Lower levels of self-efficacy are related to both higher test anxiety and to greater decrements in task performance. (Hembree, 1988) Variables found to be related to test anxiety in previous research included gender, class standing (undergraduate or graduate), number of prior math courses and years since one's last math course. (Kagan, 1987)

In this study (Bandolos & Yates, 1995) attributions for success and failure were given. For the success situation, the statement was "You get an A on your statistics test." The failure presented was "You fail a statistics course that is required for your program."

For each situation, students are required to state what the one major cause of the event would be for them, following the procedures recommended by Hedl (1990).

The test anxiety scores were derived from 8 worry and 8 emotionality items with directions to "use the scale below to rate the items". (Bandolos & Yates, 1995) Examples of worry items are "thoughts of doing poorly interfere with my concentration on test" and "I freeze up on important tests". Emotionality was measured by items such as "while taking tests I have an uneasy, upset feeling" and "during tests I feel very tense". (Bandolos & Yates, 1995)

The study found that students tended to over generalize the importance of math competence. While completing the anxiety data, students may not have been able to disassociate their general test anxiety with their anxiety about taking the math course. The perceived self-efficacy was found to have both a significant negative relationship with general test anxiety-worry, general test anxiety-emotionality and math test anxiety-emotionality and a significant positive relationship with achievement.

There was a lack of direct path between prior math courses and math self-concept. (Bandolos & Yates, 1995) A possible reason for that may have been that one's self-concept is more a function of the group with which one compares oneself than of the amount on preparation one has. If this were true, the more experience in math courses could create a tendency toward unrealistic upward expectations with a group whose actual ability exceeds that of the individual. Goethals, Messick, & Allison (1991) suggested that this may be especially true for women because they have found that women are less likely than men to make favorable social comparisons about intellectual ability.

Bandolos & Yates (1995) reported both gender groups attributing failure to a lack of effort consistently reported lower levels of test anxiety than did those citing either ability or external forces, whereas those attributing success to external causes reported higher levels of test anxiety. This makes logical sense because those who attribute success to external forces would not have any control over those forces causing the students to place the power to succeed in someone else's hands.

Ashcraft conducted a study in 2002 regarding math anxiety but found test anxiety to be a part of the problem as well. He set up the tests so that the level of difficulty for each question increased from beginning to end. The format allowed the researchers to see exactly when math anxiety presented itself. He found that there was very little anxiety for the first half of the test because the questions were very basic. Mathematics anxiety began when mixed fractions, percentages, factoring and equations with unknowns were introduced. Ashcraft also found that the participants had substantially different levels of math and test anxiety depending on how they were tested. The subjects who were tested with paper and pencil had much less anxiety than those who were timed and asked to solve the problems mentally. They were not burdened with the stress of being required to answer the questions under pressure.

Tsui & Mazzacco (2007) conducted a study that looked at the effects of math anxiety on timed versus untimed math testing. They used the Mathematics Anxiety Rating Scale – Elementary (MARS-E) that was developed by Suinn et al. (1988) for use with fourth and sixth graders. The MARS-E is a 26 item Likert-type survey with items such as "Mark how nervous you feel if you had to add up a cash register receipt after you bought several things" and "Mark how nervous you feel thinking about a math test an

hour before the test. To increase the likelihood that a high MARS-E score was specific to math anxiety, it was important to determine whether participants had general anxiety disorder. Children were tested for general anxiety disorder and those identified with the disorder were then excluded from the study. This ensured that results from the study were focused solely on mathematics anxiety. (Tsui & Mazzocco, 2007)

The children were put into two groups. One group was given a timed test first and an untimed test second. The other group was given an untimed test first and the timed test second. The study showed that math performance was significantly less accurate during timed testing, but only when the timed test was given first. Among those children there was an absence of test familiarity and the presence of time-pressure which could explain the poorer test performance.

Arem (1993) believes that test anxiety is three fold: poor test preparation and test-taking strategies, psychological pressures, and poor health habits. With emphasis on paper and pencil and standardized testing, a great deal of pressure is placed on our students. Teachers need to consider other alternative forms of assessment that can help students gain confidence. Journal writing, self-reflections, portfolios, and interviews/observations are just a few alternatives that can take the pressure off the student to always perform well on a right or wrong paper-and-pencil test. (Furner & Duffy, 2002)

Chapter Two: Causes:

Working Memory Capacity

Until this integrated research was begun, no one had considered whether math anxiety had any on-line effect on an individual's math performance, that is, an effect on underlying cognitive processes as the individual performs a math task. (Ashcraft & Kirk, 2001) Much of the literature will agree that math anxiety directly affects math performance which in turn affects the student's choices of courses and careers. Individuals with high math anxiety take fewer math courses, earn lower grades in the classes they do take, and demonstrate lower math achievement and aptitude than their counterparts with lower math anxiety (Ashcraft & Kirk, 2001)

The review of literature by the researchers Ashcraft and Kirk shows that math anxiety does not affect simple math problems such as adding and multiplication of single digit numbers (i.e.: 7 + 9, 6 x 8) They found that those with high math anxiety have difficulty with two-column addition problems (i.e.: 27 + 18) owing largely to the carry operation. When such problems were answered correctly, the time estimate for the embedded carry operation was nearly three times as long for the high anxiety participants as it was for the low anxiety participants. (Faust et al., 1996) For the single digit addition problems the error rate was 0.2% to 2.1%. For the two digit addition problems that needed the carry operation the error rate was 5.2% to 9.4%.

The capacity of working memory was closely related to skill in arithmetic problem solving. The higher the capacity of working memory, the faster the component processes were. (Geary & Widaman, 1992) The current study confirmed this. It found that working memory was negatively associated with math anxiety. The possibility exists

that the lower working memory capacity that seems characteristic of high math anxious individuals may be at least partially responsible for the performance decrements commonly found with math anxiety. This reduced working memory capacity disrupts information processing in arithmetic and math tasks. (Ashcraft & Kirk, 2001)

In the second study, Ashcraft and Kirk hypothesized that math anxiety disrupts working memory by using on-line mental addition task, in which participants see the problem and are timed as they produce its answer verbally. The more difficult the problems, especially those with the carry operation, showed increased solution latencies and dramatically higher error rates under high-memory-load conditions. This effect was interpreted to mean that more difficult addition problems rely significantly on working memory because performance of them was compromised when the system was also tasked with the memory load task. When carrying was performed concurrently with a task that placed heavy demands on working memory, performance deteriorated sharply for the high math anxiety group. This deterioration was not as pronounced at lesser degrees of problem difficulty or on problems not requiring the carry operation, and it was considerably weaker for participants at the low math anxiety level. (Ashcraft & Kirk, 2001)

There was a reduction of working memory capacity for high math anxiety individuals when their anxiety is aroused. The anxiety reaction is one of preoccupation with intrusive thoughts and worry. Because such thoughts and worry are attended, they consume a portion of the limited resources of working memory. This reduces the available pool of resources to be deployed for task-relevant processing. The draining of resources implies continued, inappropriate attention to the cognitive components of the

math-anxiety reaction and to intrusive thoughts, worry, and preoccupation with performance evaluation. Implausible is the notion that lower working capacity is a precursor to math anxiety. If it were then math anxiety should also affect cognitive performance in other domains. Instead they suggest that the working memory disruption is temporary. (Ashcraft & Kirk, 2001)

less likely as adults to pass on the importance of that domain to their own children. They also believe that this process may be the reason for a reported small difference favoring white students over black students with regard to math concepts. There was no difference between the races with regard to math computations because they are straightforward tasks where math concepts imply an in-depth understanding that can be influenced by other sources.

According to Reglin (1991) the assumption is that math anxieties exist in rural minority teachers also because they do not have a strong math background and they are choosing not to pursue a doctorate in education because they need to have a thorough understanding of data analysis. Reglin believes that blacks have a tendency to score lower on tests than whites and that it is especially true of teacher-certification and teacher-admission tests. His study was designed to investigate the effectiveness of a structured computer orientation and a mathematics review program (COMRP). This program was designed to reduce the anxieties of the educators.

The group chosen for the study consisted of black rural teachers who had no extensive coursework in computers or mathematics and lacked extensive experience in working with computers. Both computer and math anxieties were more likely to occur in these individuals. There were two groups: the COMRP group and the non-COMRP group. The COMRP group was given the same program based on lecture and demonstrations on data analysis concepts and procedures as the non-COMRP group plus a five hour COMRP program.

The results of the study showed significant statistical differences in the posttest scores with regard to instruction. The teachers in the COMRP group reduced their anxieties regarding computers as well as math more so than the non-COMRP group.

It is safe to assume that with proper instruction and enough time spent practicing mathematical procedures that a student's math anxieties can be greatly reduced regardless of race. It is the fear of the unknown that drives many students to avoid math classes altogether. If they spend more time practicing math and acquiring more assistance from the teachers they would most likely lower their own anxieties. (Reglin, 1991)

Chapter Two: Gender Differences:

There are differences in math anxiety with regard to gender. In early grades, there is no significant difference in the math anxiety experience in either gender, but females exhibit more math anxiety in secondary school and college. (Malinsky, Ross, Pannells & McJunkin, 2006)

The NCTM has 5 goals in the Curriculum and Evaluation Standards for School Mathematics. Two of them focus on the attitudes of students: valuing mathematics and becoming confident in one's ability. Gender differences in attitudes toward math are an important topic to study. These differences carry into adulthood and directly affect what majors are taken in college and what careers are chosen based on those selections.

The study conducted by Tocci & Engelhard (1991) included 3,846 students in the eighth grade: 2,059 girls and 1,787 boys. The goals of the study were to see if there is a relationship between gender and attitudes toward math. The tests given assessed the students personal views of themselves as learners of math, their views of the usefulness and importance of math in society, the extent to which math is viewed as a male domain and the extent to which the students were anxious about math.

Small but significant differences were seen in perceived usefulness of math in society and anxiety about math and large differences on the sex stereotyping of mathematics as a male domain. The females believe more strongly that studying mathematics is as appropriate for them as it is for their male peers. There was a positive direct relationship between achievement and positive perceptions of their experiences

with mathematics, the usefulness of mathematics in society and the stereotype that math is a male domain.

Interestingly, Austin & Wadlington (1992) conducted a study the following year of the math beliefs of teachers. They found that teachers who were surveyed agreed that the stereotype "men are better at math than women" is not an accurate statement.
A study was conducted by Campbell and Evans (1997) at a Catholic college preparatory high school. One class was made up of 11 females while the other class contained 4 females and 7 males. They were given a MARS-A test, which is an adolescent version of the original MARS test for college students, at the beginning of the school year and then again at the end of the school year. The Math Anxiety Rating Score (MARS) is a 98 item self-report inventory with a Likert-type format. The MARS has high reliability with an internal consistency reliability coefficient of 0.97 and a test-retest reliability coefficient of 0.78. High scores on the MARS are indicative of greater math anxiety.

The results of the study showed that the females flourished in the single-sex environment compared to the coed class. The anxiety of the single-sex female class decreased as the year progressed and the anxiety of the females in the coed class increased throughout the year. The females in the single-sex class will be more likely to continue with mathematics courses once they reach the college level because of their positive experience in high school. (Campbell & Evans, 1997)

The MARS has been recommended as a quality screening tool for use with college students. Zettle & Houghton's (1998) study was concerned with the ability of students to "fake" responses based on social desirability during the MARS. The study found that while female participants reported slightly higher levels of math anxiety as

assessed by the MARS, this difference was not significant. The number of male college students experiencing math anxiety may be underestimated because it is believed to be less socially desirable for them to show any anxieties in math and/or any deficiencies in their math skills. As a result, it may be said that it is more socially acceptable for females than males to admit to experiencing math anxiety. (Zettle & Houghton, 1998)

Stereotypes regarding the mathematical abilities of females versus males exist. These stereotypes reflect beliefs that females can not do math as well as males, females have an inferior ability to visualize three dimensional objects compared to males and females report more math anxiety than males. (Hebert & Furner, 1997) Because of this anxiety, women may prematurely exclude themselves from career opportunities by not continuing math courses in high school and college. (Hall, Davis, Bolen, & Chia, 1999)

Studies have shown that anything that reminds women or minorities of their stigmatized identity can reduce their performance on a stereotype-relevant task. (Johns, Schmader & Martens, 2005) The potential consequences of this phenomenon extend beyond just test performance; stereotype-threat may also reduce motivation to achieve in stereotype-relevant domains. (Davies, Spencer, Quinn & Gerhardstein, 2002) Exposure to positive role models, (Marx & Roman, 2002) testing in same sex environments, (Inzlicht & Ben-Zeev, 2000) and instructions to view intelligence as a malleable trait (Aronson, Fried, & Good, 2002) are three strategies that increase the academic performance of stigmatized individuals. (Johns, Schmader & Martens, 2005)

On one hand, teaching about the stereotype threat might exacerbate the very problem it describes. Research on automatic social behavior (Bargh & Chartrand, 1999) suggests that mere stereotype activation can produce stereotype-consistent behaviors.

(Wheeler & Petty, 2001) If stereotype threat is caused by a concern that one's performance might be seen by other people as confirming negative group stereotypes, then learning about any factor that debilitates one's performance might only increase that concern. (Johns, Schmader, & Martens, 2005)

On the other hand, one can develop a more optimistic prediction about the effect of learning about stereotype threat. Learning about the effects of stereotype threat might provide individuals with an external attribution for their anxiety during a stereotype-relevant task. This attribution might release stereotype-threatened individuals from assuming that the increased arousal they are feeling indicates they do not have the ability to do well. Thus teaching students about stereotype threat might inoculate them against its effect. (Johns, Schmader, & Martens, 2005)

The study by Johns, Schmader, & Martens (2005) found that teaching about stereotype threat improved women's performance despite the fact that they were highly aware of the stereotype deprecation women's math ability and believed that the researcher expected men to outperform women. This confirmed the hypothesis of the researcher that knowledge of stereotype threat improves performance.

Though in the past men have been considered superior to women in mathematics, the gap between the genders is closing. (Campbell & Evans, 1997) Over the years more and more women are taking math courses and finding careers where mathematics is frequently used. Part of our current curriculum should include ways to address and prevent math anxiety. In order to balance the number of women in math courses in college, it is necessary to strive for higher math self-concepts and positive attitudes regarding math in women during the elementary, middle and high school levels.

Chapter Two: Assessing pre-service teachers:

According to Ingersoll (1999) research in North America has indicated that many teachers of mathematics at both the elementary and secondary school levels have relatively weak academic backgrounds in the subject. Ingersoll also noted that in the United States, 26.5% of grade 7 – 12 mathematics classes were taught by teachers who did not have a major or a minor in mathematics. (Brady & Boyd, 2005)

Battista (1986) noted a lack of knowledge and poor attitudes towards mathematics exhibited by many pre-service elementary teachers may inhibit their learning and later use of effective methods for teaching mathematics. Mathematics anxious teachers may serve to foster the early development of math anxiety among their students. Although math anxiety may have serious consequences in both daily life and in work, math anxiety has its roots in teaching and teachers. (Williams, 1988) Concern that teachers' attitudes toward mathematics may affect more than their students' values and attitudes toward mathematics; these attitudes may affect the effectiveness of the teaching itself. (Teague & Austin-Martin, 1981) Elementary school teachers scoring higher on measures of math anxiety have been found to spend less time planning mathematics lessons and using mathematics instruction time for non-math related activities more often than their non-math-anxious colleagues. (Swetman et al., 1993)

These important findings have prompted many researchers to evaluate pre-service teachers for mathematics anxiety. A pre-service teacher is a student who is studying to become a teacher. The PPST is the PreProfessional Skills Test. It consists of three sections testing the knowledge and skills for reading, math and writing. The results from

this test are used to create intervention programs for pre-service education students that focus on alleviating negative math attitudes as well as developing both constructive math test strategies and specific math skills. (Harrington & Davis, 1992)

The students in Harrington & Davis' (1992) study were enrolled in a midwestern metropolitan university. Forty students were chosen for this study. These students were registered to take the PPST at their university. They were given a sample PPST and a math anxiety measure. The math anxiety measure contained 38 items that were rated on a five point Likert-type scale ranging from "not at all" (1 point) to "very much" (5 points). The students were also asked for their gender, age, GPA, previous math courses taken and how many hours they spent in the Learning Center provided.

The sample test scores were then compared to the actual test scores of the PPST. The researchers determined that the variable that dictated how the students would do on the actual PPST test was the sample PPST scores and the math anxiety measure. Their gender, age, GPA, math courses and Learning Center hours were less significant. The math anxiety level varied directly to the number of hours spent in the Learning Center. However, the math anxiety measure varied indirectly to the score on the sample PPST.

Harrington & Davis (1992) reported that an extensive preparatory program was developed based on the study's conclusion that math anxiety was a critical factor on PPST math performance and needed to be addressed. The group included a math specialist and a math resource person who were there to help with any math skill issues. There was also time allotted for the students to work on their anxious feelings. In addition, they were given a test anxiety video that helped them to work individually on relaxation and breathing exercises.

In 1999, Trujillo & Hadfield conducted a study on highly anxious pre-service teachers. The Revised Mathematics Anxiety Rating Scale (R-MARS) was given to 50 pre-service elementary teachers. The R-MARS contains 24 questions that were developed from the MARS, 98 question test, regarding mathematics anxiety. (Richardson & Suinn, 1972) The five most anxious were identified and chosen for this study. They were asked questions regarding negative school experiences, lack of family support, and general test anxieties.

There is particular concern in the case of elementary teachers, because it has been reported that a large portion of them experience math anxiety. (Levine, 1996) Math anxious elementary school teachers may pass their anxieties on to their students. These teachers tend to use traditional teaching methods such as lecture and teach skills rather than concepts. (Brush, 1991) This is contrary to the more recent teaching techniques that include cooperative learning and the use of projects. (NCTM 1989)

The purpose of this study was to implement an in-depth exploration of the early school mathematics experiences of highly anxious pre-service elementary teachers and how they planned to overcome their mathematics anxieties. All of there responses to the interview questions were placed into 10 categories: view of mathematics, self-concept in mathematics, elementary school experiences, secondary school experiences, college experiences, examples of good math teachers, examples of bad math teachers, family influences, math test anxiety, and plan for teaching math to children. A synthesis of their finds was composed. (Trujillo & Hadfield, 1999)

The five participants in this intense study were female. The five women all had several negative experiences in the mathematics classroom. None of them had positive

support at home and all of them suffer from severe math anxiety. Despite these disadvantages, these women plan to make mathematics meaningful to their students.

Prevention of math anxiety would be ideal. However, it is not possible to completely eradicate the problem. It is more likely that the issue will need to be dealt with while the preservice teachers are in college with methods courses in mathematics or through math anxiety clinics offered to existing teachers. These clinics have been known to be successful. (Hembree, 1990) The most effective programs typically focus on study skills to build confidence, combined with relaxation techniques to reduce the physiological aspects of the anxiety. (Bander, Russell, and Zamostny, 1982) The only problem is that the clinics are limited in their availability.

Another solution would be to not require math anxious elementary teachers to teach math. Many math educators are supporters of the placement of a math specialist in all elementary schools. (Miller, 1992) Some schools even allow these specialists to prepare a separate classroom complete with sets of manipulatives so that each class can attend on a rotating basis. (Tankersley, 1993)

A final solution suggested by Trujillo and Hadfield (1999) is to provide elementary mathematics methods courses and professional development opportunities that reduce mathematic anxieties through the development and delivery of cutting edge lesson in mathematics for elementary school children. These courses can incorporate activities that build conceptual learning, require mathematical reasoning, provide connections within mathematics and address concerns through a problem solving approach. (NCTM, 1989)

Vinson (2001) brought made recommendation a reality. Her goal was to compare pre-service teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. In her study, students were given a MARS pretest to confirm their level of math anxiety. The treatment was a hands-on approach to teaching mathematics with manipulatives in the methods and materials courses for pre-service teachers. The students were then given the same MARS test after the courses were complete. The college courses were offered in quarters. Four different quarters were covered. Each of the quarters showed a drop in anxiety from the beginning of the course to the end. The results were as follows: the fall semester dropped by a score of 14.92. The winter dropped 48.06, the spring dropped 27.26 and the summer dropped 30.22. The fall quarter was the professor's first time teaching at that particular as well as the first time he taught a mathematics methods course. Therefore, the professor probably exhibited more stress and uncertainty that term compared to the subsequent terms. (Vinson, 2001) Which tells us that the professors own anxieties directly affected the anxieties of his students.

Teachers have an impact upon their students' mathematics anxiety levels. In this study, as the professor gained experience with the subject and the setting, anxiety levels were reduced in the students. The students were interviewed at the end of the quarters. They indicated that they were better able to understand mathematics concepts and procedures when they were presented on the pictorial and conceptual levels. As an effect, what they understand, they are able to teach. What they are able to teach effectively will reduce the anxiety levels of their future students.

Chapter Three: Application

My study:

The goal of my study was to determine what mathematics anxieties elementary, middle and high school teachers have, how those teachers diagnosed math anxiety in their students and what teaching strategies they use to help alleviate math anxiety in their students. I was also interested to know if they believed their anxieties had any impact on their student.

The participants were teachers with whom I have worked with directly and indirectly in the past. Ten of the fifteen teachers surveyed agreed to participate. The other five were sent a copy of the questionnaire and asked to participate in an attached cover letter. I created a questionnaire for teachers that included 12 questions regarding math anxiety. I sent out 15 questionnaires and I received only 10 of them in return. I was fortunate, however, to receive representation from elementary, middle and high school teachers.

My goal was to interview teachers of all grade levels to see if they had math anxieties themselves. If so, do they believe these anxieties contribute to the students' math anxiety problems or is there a way to keep them separate. I wanted to know if these teachers were able to diagnose math anxiety in a student and what instructional strategies or teaching techniques, if any, were utilized to help him.

There was only one teacher of the ten participants who claimed to have any level of math anxiety. This teacher has only a year of experience and is still learning the best teaching techniques to use with the students. He said that if he were asked to teach in the higher grades, his anxieties would increase because he has not worked with that level of

math in a while. He said he would "need some brushing up" in order to be confident enough to teach. Seven of the ten teachers in this study had anxieties about making math connections for the students. They question whether the students are engaged in the classroom and if they really understand the concepts.

Two middle school teachers and one fifth grade teacher claimed that the way they deal with their own anxieties is to create a student-centered classroom. The students are allowed to use manipulatives and work in groups. The teachers gave instructions regarding what was expected in the groups and the students were there to help each other through the problems. The teachers claimed that this alleviated their anxiety and allowed for the students to make their own connections to the math.

Several of the teachers did not feel taking higher level math courses in college would have helped them with their current math anxieties. They claim that the higher level courses cause math anxiety and are too advanced to help with elementary, middle and high school math.

None of the teachers felt their own math anxieties affected the students in a negative way. Three of the teachers said that their math anxieties helped them to understand the math anxieties of their students. This understanding has helped them to be more sensitive to the students and more creative in their lesson planning.

The symptoms of mathematics anxiety in the students recognized by the teachers were low test scores, reluctance to participate, homework not done or mostly wrong, low confidence, high frustration, avoidance, and a refusal to try. The teachers said the best predictor of math anxiety is when the students verbalize their distain for the subject by stating "I hate math", "I'm not good at math" or "I can't do this".

When asked if there were noticeable differences in race, gender or grade level, only one high school teacher said she has witnessed a gender difference. She stated that females had a tendency to have higher math anxieties but also had better grades. None of the teachers have experienced a racial difference in math anxiety and none of them saw a difference between grade levels.

There were two popular responses when asked how the students' anxieties affected the teacher. The teachers either said they were challenged to find new ways to reach the student and explain the concepts or they said they became very frustrated. However, all of the teachers had recommendations of teaching techniques and instructional strategies beneficial to students with math anxieties. They included one-on-one help, frequent checks, guided questions, positive comments, more attention in class, discuss strategies with student, hands-on instruction with manipulatives, and create opportunities for the student to succeed.

Alternatively, the teachers also gave several teaching techniques and instructional strategies that were detrimental to a student with math anxieties. They consisted of showing disappointment, putting the student "on the spot" in front of the class, teaching through lecture only with no group work, making class work too difficult, making homework assignments too large, neglecting the needs of the student, and not giving wait-time to the student.

Zemelman, Daniels & Hyde (1998) put together best practices for teaching math: use of manipulatives, cooperative group work, discussion, questioning and making conjectures, justification of thinking, writing in math for thinking, expressing feelings and solving problems, and use of problem solving approaches, making content

integration a part of instruction, use of calculators, computers and all technology, serve as a facilitator of learning and include assessments of learning as a part of instruction. The answers to the questionnaire were not surprising because they follow along with the research I have done for this project.

This study confirmed that teachers as well as students carry mathematics anxieties. Reducing math anxiety is much different than preventing math anxiety. Teachers need to help students understand how their math anxiety came about in the first place. They almost have to take on the role of a counselor to help students lower or overcome their anxiety toward math.

Future studies on this topic would benefit if they were not conducted on a voluntary basis. It is difficult to obtain accurate statistics on the causes, racial and gender differences and cures of mathematics anxiety if those who have the anxieties choose not to participate. Cates & Rhymer (2003) encountered similar difficulties. Only 10% of those who could have participated in their study did so. They believed that those with the higher math anxieties avoided the study altogether. If the assessment of mathematics anxiety was a part of the curriculum for all schools, then we would be able to obtain accurate data to assist in creating intervention programs to aid in lowering the mathematics anxieties of our students.

Grade _____

Date _____

Math Anxiety Questionnaire for Teachers

Definition: Math Anxiety is the irrational fear of learning and performing mathematics that creates intense emotional feelings.

1. What anxieties, if any, do you have with regard to doing mathematics?

2. What anxieties, if any, do you have with regard to teaching mathematics?

3. If math anxieties exist, what have you done in the past to deal with them?

4. Do you think attending more mathematics courses during your own education would help with any math anxieties you may have?

5. Do you think attending higher level courses would have helped?

6. Do you believe that your own math anxieties may affect your students? If so, in what way?

7. What are some symptoms that cause you to consider math anxiety in your students?

8. Do you notice an imbalance in your students' math anxieties with regard to the following?

   Gender:

   Race:

   Grade Level:

9. What steps do you take when you suspect math anxieties are present in one of your students?

10. How do your students' math anxieties affect you as a teacher?

11. What teaching techniques or instructional strategies are beneficial for students with math anxieties?

12. What teaching techniques or instructional strategies do you feel can be detrimental to a student with math anxieties?

Chapter Four: Solutions

During the 1980's it was uncommon for elementary math teachers to utilize cooperative learning or group work as well as manipulative and concrete materials. (Stodolsky, 1985) Math was taught is a straightforward manner. The teacher lectured about the new math topic and then the students worked on practice problems. Though the practice of discussion and interaction among students was widely utilized in other subject matters, it was not often done in the mathematics classroom.

Carpenter et al., (1981) conducted a study of student attitudes and opinions regarding the subject of mathematics. The study showed that 9 year olds found math as their best-liked subject, 13 year olds ranked it their second best-liked subject and 17 year olds ranked it as their least-liked subject. This trend has been confirmed over and over again with subsequent studies. It seems students truly enjoy math in the earlier years but as the content becomes more sophisticated and complex the enjoyment is replaced with dread. Interestingly, a study by Brush (1979) found that although student attitudes towards math declines through the years there is no decrease across the school years in students' perception that mathematics is important.

Stodolsky (1985) observed math and social study fifth grade classes. She concluded that though the students were taught both subjects by the same teacher in the same classroom the instructional techniques used by the teacher were very different depending on which subject matter was being taught. All of the math classes were taught in the same manner. The teacher presented new material and the students practiced problems at their desks alone. However, in the social studies classes the teacher used a

variety of different teaching techniques and the students were allowed to work in groups, carry on conversations about the subject matter and use a variety of resource materials such as newspapers, magazines, maps and encyclopedias. The students were also encouraged to become independent learners and to develop their research skills. (Stodolsky, 1985)

It seems reasonable to hypothesize that the nature of repetitive and early experiences with learning each subject matter will impact on later attitudes and expectations about learning each subject. (Stodolsky, 1985) Rote learning can be very uninteresting and tedious while cooperative learning, group discussions and the use of multiple resources can create an enjoyable learning environment.

Stodolsky claims that the development of dependence between the math teacher and the math student over many years is the root of the problem. She believes that because of this dependence, students often believe that the teacher is their only learning source. If the student does not understand the instruction they are stumped. If you are stumped your excuse, which is culturally accepted, is that you are "no good at math".

Teachers can be part of the solution. It is always important for teachers to be seen as helpful and not hurtful. At the beginning of each school year the teacher should introduce himself as human and not an expert at math without faults. If a student sees that the teacher has some faults and difficulties also, he will be able to relate better and be more willing to ask for assistance when needed. This relationship will help the student reduce his anxieties because he will feel more support than judgment.

The first rule in determining if a student has math and/or test anxieties is NOT to test them. It is necessary to have a candid conversation with the student. The teacher

should try to build the confidence of the student. Many students think that if a teacher knows there is past difficulty with math that they will be considered a problem before the school year even starts. Many of these students will be found sitting in the back of the classroom trying to hide from the problem. These students feel that they are alone with this problem and feel very isolated.

Miller & Mitchell (1994) believe in a two phase treatment to deal with math anxiety. Step 1 is through special tutoring. During these sessions, manipulatives, real world examples, and different conceptual explanations are presented and utilized. Step 2 consists of using alternative methods of evaluation such as interviews, tutoring, writing assignments, responses during class, board work, small groups, homework, independent projects.

The utilization of more hands-on exercises in the classroom will allow the students to learn in a low-anxiety atmosphere. Students are often afraid to be called on to answer questions in front of their peers. Though it is necessary for teachers to ask questions to assess understanding of the current topic, it would be wise to allow for group activities with manipulatives so the students could be assessed in a relaxed format.

- Miller and Mitchell (1994) believe that test anxiety can also be a factor within math anxiety. It may be necessary to test the student without peers in the room. Formal tests where students sit down in a room together and answer a series of questions and solve a group of problems can be fine to some but can be an inadequate way to assess others. Because children are different in how they learn, they are also different in how they can express what they have learned. It would be beneficial to the students if

alternative forms of assessment were given to allow for a greater chance of success with respect to grades.

These researchers suggested it is important to call the test by a different name such as a tutoring session or one-on-one time so there is less pressure of failure. Once that test is complete and graded have the student take a similar test in the classroom with peers but tell him that the test score cannot be lower that the one taken in private. This will allow the student to become comfortable taking tests along with peers without the fear of failure causing anxiety. Once the student begins to have similar grades on both tests, he/she should then be ready to take all future tests with his/her peers. Communication regarding the process should be conveyed to the parents to ensure their advocacy for success. Students should be able to track their own success. This will give them the reinforcement they need to know they are on the correct path toward overcoming their anxiety issues. (Miller & Mitchell, 1994)

Bibliotherapy is a solution to overcome math anxiety that is based more on self-esteem and self-concept than on mathematic content. (Hebert & Furner, 1997) Often a student's feelings toward mathematics have a greater impact on his success than his math abilities does. Bibliotherapy is a strategy to help students discuss their feelings and prevent or reduce math anxieties. It is a process that uses reading as therapy. When students read they have a tendency to relate to the characters. With this identification comes a sense of tension relief called catharsis. As the students read they learn vicariously through the characters. Readers gain insight on how to solve problems. (Hebert & Furner, 1997)

In 1998, Sgoutag-Emch & Johnson, conducted a combined quantitative and qualitative research project at the University of San Diego regarding math anxiety, specifically statistics classes. It is commonly known that statistic courses are required for a variety of majors. They can be one of the most rigorous curriculums and large producers of anxiety for students. The anxiety experienced by some can actually cause avoidance of certain majors that include mathematics courses. The researchers' main focus was to know if journal writing throughout the semester would be therapeutic to those who possess high levels of math anxiety.

There were 44 participants in the study. There were 11 men and 33 women. The average age was 20. The setting for the research was two statistics courses offered at the university. Both classes had the same instructor which meant that the exams were the same and the grading policies were the same for all participants. The study was done on a voluntary basis. There were several questionnaires given before, during and after the semester:

- **Questionnaires given on first day only:**

  Basic Math Test: basic math and algebra functions

  Spielberger Trait Anxiety Inventory: level at which an individual has a tendency to perceive stressful situations and level of general anxiety

  Spielberger Test Anxiety Inventory: measured total test anxiety, worry scale and emotionality scale.

  Achievement Anxiety Test: measured facilitating and debilitating anxiety with regard to test taking.

- **Questionnaires given first and last day:**

  Statistics Anxiety Inventory: measured anxiety about statistics content and anxiety about statistics performance and problem-solving skills.

  Statistics Attitude Scale: measured usefulness of statistics and anxieties of students who are required to take the course.

- **Questionnaires given on last day only:**

  Spielberger State Anxiety questionnaire:

  Perceived Performance and Difficulty Scales asked students how they thought they performed and how difficult they felt the final exam was for them.

  Journal Efficacy Scales asked students their perceived effectiveness of the journal writing had on reducing their anxiety and increasing their understanding of the course content.

The test group of students was given journals to write in. They were required to write about any feelings, frustrations, and thoughts they were experiencing at the end of each class period. Students were also required to take saliva samples so they could be tested for cortisol levels. Cortisol is a hormone that is directly related to the amount of anxiety a person has. Saliva was collected before the exams and a sample immediately following the exams. The saliva was then shipped in dry ice to a laboratory for analysis.

All of the participants rated neutral levels for both statistics anxiety and attitude inventories. Neither group had high levels of anxiety or a negative attitude about the course. These neutral levels may be the explanation as to why there were no statistically significant levels of change in anxiety for either group. The cortisol levels did not change

significantly as well. Overall the control group showed a small increase in anxiety where the journal group showed a small decrease in anxiety. It was suggested that journal writing may be most effective on those who are extremely anxious when taking math courses. (Sgoutas-Emch & Johnson, 1998)

Mathematics is an essential part of many programs and is also a major barrier for many students (Benn & Burton 1994). It is believed that this barrier is built up by such things as bad school experiences due to bad teaching, lack of understanding, or lack of relevance. (Benn & Burton 1993) The philosophy of the on-line mathematics program created by Taylor & Mohr (2001) involves placing the students at the center of the learning process where they are encouraged to manage and take responsibility for their study and learning. The course is characterized by its student-centered approach using reflective practice techniques through diary and essay writing. It was designed to address issues and beliefs about attitudes toward mathematics as well as math study skills. Its goal is to alleviate math anxiety thus increasing the confidence and mathematics skills of the students. (Taylor & Mohr, 2001)

Students were asked to keep learning diaries throughout the course. The learning diaries allow students to reflect on their learning experience and to make personal contact with their tutor. The students were required to write an essay at the end of the course. The essay asks the students to reflect on their whole mathematical learning experience, viewing any changes in attitudes and gathering together study strategies that worked for future reference. The text materials used were all written with as little math jargon as possible to make them more accessible to the novice students. Formal math language was introduced at a slow pace. The activities and content were grouped so that it allowed

students to experience early success and build confidence, knowledge, and skills gradually. All activities had fully worked solutions with problem solving prompts to guide the student through the steps as appropriate. (Taylor & Mohr, 2001)

After the on-line course was complete the students were given a survey. Of the 60 responses, 46 (77%) showed a positive change in their feelings of confidence doing everyday mathematics. The two drawbacks of this program are that it was created months in advance; it did not have the feedback of the students and secondly, is not available to those students who do not have accessibility to the technology.

Furner & Duffy (2002) suggested that teachers take the initiative and give a simple survey, "Mathitude Survey", to their students at the beginning of the year to get a better feeling for the level of their students' math anxiety and in turn allow them to better address and be sensitive to those who are feeling math anxious. The Mathitude Survey was based on the material from Principles and Standards for School Mathematics by National Counsel of Teachers of Mathematics, 2000

1. When I hear the word math, I ...
2. My favorite thing in math is ...
3. My least favorite thing in math is ...
4. If I could ask for one thing in math it would be ...
5. My favorite teacher for math is ....because ...
6. If math were a color, it would be ...
7. If math were an animal, it would be ...
8. My favorite subject is ...because ...

9. Math stresses me out: True or False. Explain if you can.

10. I am a good math problem solver: True or False. Explain if you can.

This survey is a great guide for teachers to really understand the feelings their students have with regard to mathematics. The teacher can use this information to tailor her lesson plans to the students needs. Hambree (1990) noted that those students who undergo effective interventions for math anxiety, such as cognitive behavior interventions, increase their math achievement scores closer to those with low math anxiety. Given that the intervention does not instruct or practice math, it follows the previous low achievement test results could be at least partially explained by the math anxiety reaction.

Math anxiety leads to a global avoidance pattern. Students avoid taking math classes, avoid careers involving math and avoid general situations that have anything to do with math. Once math anxiety is established, it seems to be supported by a variety of cultural attitudes that undermine math achievement such as "math is hard" or "one either is or is not good at math, regardless of how hard one works". (Ashcraft & Krause, 2007)

According to Perry (2004) most teachers would agree that students' anxieties stem from the fear of failure and a feeling of inadequacy. Often math anxiety starts at a young age. A single insensitive math teacher can create a recurring math anxiety problem that may be difficult to overcome. It is also possible for a student to have a superficial understanding of mathematics limited to computational skills, with little conceptual understanding and hence no mental framework within which to organize his/her knowledge. Connections to prior knowledge are not made. As a result, this

causes the student to forget what he/she has learned quickly and to experience chronic frustration. (Perry, 2004)

Nearly every student has some positive experience with mathematics. Perry believes that thinking about this happy experience and especially writing about it, reminds an individual that he has the potential to be successful in mathematics, and serves as an inspiration. This instructional strategy allows for the student to be reminded of his continuing accomplishments in math. Though this can be a powerful and positive teaching technique, it is also imperative that positive validation come from the teacher as well.

Chapter Five: Conclusion

From the research I have done, the best way to combat math anxiety is to prevent it from the beginning. The best methods for the prevention of math anxiety are to accommodate different learning styles, have a variety of testing environments, design positive experiences in math, remove the importance of ego in the classroom, make math relevant, let students have input in their own evaluations, and emphasize the importance of original, quality thinking rather than manipulation of formulas. (Furner & Duffy, 2002) The teachers in my study agree with the research in that math anxiety exists in all levels of students, it can cause mathematics performance problems for students and it is necessary to create intervention programs in order to reduce or eliminate the issue.

Since it has been shown in the literature that teachers and parents directly affect the math anxiety of children, it would be wise to focus on how to affect the children positively. It would be beneficial to start with the children in elementary school before math anxiety exists. Many students may never achieve success in mathematics without the emotional support and confidence building skills of teachers and parents. Teachers must keep in mind when creating lesson plans that what they say and how they say it has as much impact on a student and the content of the course. It is important for teachers to alter lesson formats and classroom activities to increase the possibilities of success for each student. Education of new elementary teachers should include classes that incorporate how to work with and speak to children positively to avoid creating anxiety. These new teachers should also learn how to control their own anxieties to avoid affecting the anxieties of the students.

Cruikskank and Sheffield (1992) wrote that they were unconvinced that elementary school children suffer from mathematics anxiety. Instead, they argued that teachers, who fail to implement positive practices, actually cause their students to learn math-anxious behavior. To avoid this teachers must show that they like math, make math enjoyable, show the use of math in everyday life, adapt instruction to the students' interests, establish short term attainable goals, provide successful activities and use meaningful methods of teaching so that math makes sense. (Vinson, 2001) It has also been suggested that teachers de-emphasize speed testing or drills and avoid competitions among students in order to further reduce the chances of math anxiety. (Lindquist 1995)

Students who are severely math anxious may opt for academic majors within the humanities, fine arts, or social sciences that require minimal coursework in mathematics. (Chipman et al., 1992) However, even students who select majors in which mathematics is not emphasized may be expected to successfully demonstrate at least a minimal competency in math as part of their general degree requirements. (Zettle & Raines, 2000) Most, if not all, colleges require students to have a basic understanding of college algebra.

Since we cannot prevent mathematics anxiety for everyone at this time, my recommendation would be to have the assessment of mathematics anxiety incorporated into all curriculums. It should be required of all teachers of mathematics classes to assess their students' math anxieties. Testing, with a version of the MARS test, the Mathitude test or any other math anxiety measure, at the beginning of the course or school year would provide valuable data for teachers. This information could be used to pinpoint where, when and how each student has trouble with math and can be used to determine

what intervention, if any, is needed. A variety of interventions also need to be created in order to meet the needs of the individual students.

We will never be able to control the attitudes, behaviors and comments of frustrated elementary, secondary and college mathematics teachers. Therefore, we must make it a requirement that math anxiety be assessed and addressed for students as well as teachers. It should be encouraged to test teachers' anxiety levels and should be required for those with math anxiety to attend workshops or conferences specially designed to help reduce if not eliminate math anxiety.

There have been many studies conducted to assess when, where, how and why mathematics anxieties exist. There have also been many studies that have supplied strategies for reducing and/or preventing math anxiety among students, preservice elementary education teachers and active teachers. However, the solutions are only beneficial if they are implemented. Obtaining assistance for math anxiety should not be on a voluntary basis. It should be a part of the curriculum for all grades from pre-school all the way through college and into to professional development of our teachers. Our goal should be to strive for higher math self-concepts and positive attitudes regarding math throughout the education experience.

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