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CERTIFICATION OF PROJECT WORK

We, the undersigned, certify that this project entitled ANXIETY IN ACTION: A study on math anxiety among college students, by Mimi E. Gulick, Candidate for the Degree of Master of Science in Education, Mathematics Education, is acceptable in form and content and demonstrates a satisfactory knowledge of the field covered by this project.

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ANXIETY IN ACTION:
A STUDY ON MATH ANXIETY AMONG COLLEGE STUDENTS

by

Mimi E. Gulick

A Master's Project
Submitted in Partial Fulfillment
of the Requirements of the Degree of
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Abstract

Math Anxiety is a term used to describe the anxious symptoms felt by those who suffer from it while confronted with mathematics. This study investigated the levels of math anxiety experienced by college students. It was hypothesized that students in non-major mathematics courses would score higher on the *Gulick Math Anxiety Scale* than their peers enrolled in mathematics courses for mostly mathematics majors. Furthermore, those students who identified themselves as having medium to high levels of math anxiety, would attribute that anxiety to a negative past experience in a mathematics classroom. Data collected was both qualitative and quantitative in nature, and revealed that students in the non-major classes scored higher on the *Gulick Math Anxiety Scale* than the students in the classes for mostly mathematics majors. The math anxiety that existed in students was highest when associated with testing anxiety, and the main reason students reported math anxiety was due to a lack of confidence.

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Introduction

This research examines the differences in the levels of math anxiety that exist among different subgroups of mainly freshmen college students, namely mathematics majors and non-mathematics majors. Students can be highly susceptible to math anxiety, which has found to be detrimental to the learning and practice of mathematics. Many individuals who suffer from this condition develop it at a young age, and without intervention it can stay with them for their entire lives. It is argued that the greatest effect math anxiety has is *math avoidance*, an individuals' reluctance to practice and study mathematics, which is of great proportion.

As an undergraduate mathematics education major, I have had the opportunity to work with individuals who have a passion for mathematics in my classes. These classmates presumably had low to non-existent levels of anxiety due to their passion, dedication to the study, and confidence in their ability to have success. Since I have become an instructor of a low-level college mathematics course, taken by non-majors to fulfill the mathematics requirement for a Bachelor's degree, I believe I have been exposed to a great deal of students who suffer from math anxiety. Reasons for this is that I have heard many of my students say how they are bad at, and dislike mathematics. Many demonstrate little confidence when they offer answers to questions in class. Very few come in for extra help, which leads me to believe many are satisfied with performing at average or below average levels, and avoid studying mathematics altogether. As I identify myself as a mathematics educator, this issue of students' math anxiety has become a great concern of mine.

It is my professional goal to help students become more confident with their ability to perform mathematical tasks, as well as be successful in their studies. Since math anxiety causes discomfort, avoidance, and a hatred for the subject, it is my belief that studying this phenomenon will aid me in reaching my professional goals.

This study focuses on math anxiety among college students enrolled in major and non-major mathematics courses, to determine the differences in math anxiety that exists among different subgroups of those students.

> *It is hypothesized that students who are enrolled in non-major mathematics courses in college will score higher on a math anxiety rating scale compared to their peers who are enrolled in mathematics courses for math majors. Furthermore, those students who identify themselves as having medium to high levels of math anxiety on a survey would attribute their anxiety to having negative past experiences in a mathematics classroom.*

This dual hypothesis was tested by administering a math anxiety scale to two sub-groups of college students. The first group included a sample of students enrolled in two MATH 110 (Mathematics in Action) sections. These students were mostly freshmen, all of whom were not registered in college as mathematics majors. The second group was enrolled in either MATH 122 (University Calculus 1) or MATH 210 (Mathematical Structure and Proof). These students were mainly mathematics majors or mathematics education majors. The scale used to determine students' math anxiety was named the *Gulick Math Anxiety Scale* (G-MAS), which is based on a 5-point Likert scale. It was developed by the principal investigator of this study, and includes items from the most highly regarded math anxiety rating scales to date, the MARS and Fennema-Sherman. Subgroup results were compared to address the first component of the hypothesis. To test the second part of the hypothesis, participants were given a survey which required them to report their believed level of math anxiety, and offer reason for why they feel that anxiety exists.

Literature Review

Math anxiety is a condition that has received attention by researchers and mathematics educators over the past few decades. The purpose of this literature review is to examine the existing research pertaining to the definition of, apparent causes and effects of, and the methods of studying math anxiety. After first defining what math anxiety is according to the literature, a motivation for why it is studied will be discussed. The argued experiences that are causes for this anxiety as well as the apparent effects of suffering from math anxiety are then examined, and again produce a reason for why the topic should be studied. Finally, research which has been done regarding scales for measuring math anxiety is reviewed.

Math Anxiety: A Definition

Anxiety itself can be thought of as a condition of basic human experience. Feelings associated with anxiety include, “panic, excitement, tension, helplessness, fear, distress, shame, inability to cope, as well as many physiological symptoms like sweaty palms, nervous stomach, difficulty breathing, and loss of ability to concentrate” (Deniz & Üldaş, 2008, p.50). Mathematics in it’s own right, is a field of study that can bring great difficulty to those who choose to study it. One can even agree with the statement “the nature of mathematics typically induces anxiety” (p. 49). The notion of becoming anxious over the subject of mathematics is a relatively new idea. It was not until 1957 when Ralph Dreger and Lewis Aiken defined *number anxiety* as the “presence of a syndrome of emotional reactions to arithmetic and mathematics” (p.344). These researchers were the first to develop a study to investigate the emotional problems that are associated with mathematics. Figure 1, found on Page 4 gives a brief description of the history of math anxiety.

Figure 1. A Brief History on the Study of Math Anxiety

1957	Ralph Dreger & Lewis Aiken first identified "a syndrome of emotional reactions to arithmetic and mathematics, tentatively designated Number Anxiety." (p. 344)
1972	Frank Richardson & Richard Suinn developed the *Mathematics Anxiety Rating Scale* (MARS), and defined Math Anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of problems in a wide variety or ordinary life and academic situations." (p.551)
1976	Elizabeth Fennema & Julia Sherman Developed the *Fennema-Sherman Mathematics Attitudes Scales* which are used in the testing of math anxiety.
1978	Sheila Tobias Published the book, *Overcoming Math Anxiety*
1982	Barbara Plake & Claire Parker developed a shortened, revised version of the MARS known as the MARS-R.

As seen in the figure above, this phenomenon has received attention from educators, psychologists, and administrators since it has been recognized as a problem. The existing research has shown math anxiety is a condition different from general anxiety, and those who suffer from it may not suffer from any other psychological problem (Betz, 1978; Dreger & Aiken, 1957). Math anxiety has received attention as it has been thought to be a cause of *math avoidance*, the small number of students involved in the study of mathematics due to a general distaste for the subject (Meece, Wigfield & Eccles, 1990).

After math anxiety was recognized as a problem in society, it was in 1972 when Richardson and Suinn gave their definition "Math anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551) which many researchers since then have accepted (Betz, 1978; Engelhard, 1990; Erden & Akgül, 1990; Hunsley 1987; Siegel, Galassi & Ware, 1985; Woodard 2004). It should be noted that not every student or individual suffering from math anxiety exhibits all symptoms of anxiety every time they are confronted with mathematics. Researchers believe that math anxiety exists in a range of levels, with the lowest level associated with moderate test anxiety (Dew & Galassi, 1983; Hunsley, 1987; Perry, 2004) and higher levels causing the actual physiological and physical symptoms.

Math anxiety has also been thought to only emerge in certain situations. Ruedy & Nirenberg (1990) define "Selective math anxiety" (p.19) as anxiety that is only apparent in particular mathematical situations. For some people, they may be competent and comfortable working with any type of mathematics except for fractions. Others may become anxious only in academic settings where they are required to complete a test or answer questions. Some individuals experience symptoms of anxiety when asked to think mathematically in real-life situations such as in balancing their checkbooks, or calculating tips at dinner (Ruedy & Nirenberg, 1990). Since symptoms of math anxiety exist in different situations for different individuals, the phenomenon can be considered to exist in the following dimensions: Academic, Everyday, Testing, and Attitude.

Due to the widespread effects that math anxiety can have on students, as well as members of society, math anxiety has been an area of research worthwhile to study regardless of the severity or prevalence of the condition in individuals, communities, or classrooms.

Math Anxiety: Why study it?

Math anxiety is considered a serious, widespread problem that exists in our society (Ruedy & Nirenberg, 1990). Because it is thought of to be a psychological problem, psychologists have done research in terms of causes and treatment (Betz, 1978). Teachers are likely to be partly responsible for math anxiety, and are great forces for change, so math anxiety is relevant for them to study.

Having knowledge of mathematics has been considered as a prerequisite in becoming a member of many occupational fields in today's technological society (Betz, 1978; Meece, Wigfield & Eccles, 1990). Mathematics has been said to be the "key to opportunity" in areas such as business, finance, healthcare, and defense (Ruedy & Nirenberg, 1990). Erden & Akgül found "*A research of National Research Council* (1989) shows that the basics of mathematics and geometry fields are essential for specialization in 75 percent of all occupations" (Erden & Akgül, 2010 p.4).

The fact that the United States has fallen behind technologically is a possible result of the deficiency of people who choose to study mathematics (Ruedy & Nirenberg, 1990; Sembera & Hovis, 1990). Evidence for the deficiency of people who study mathematics comes from the claims that the condition of math anxiety is widespread (Betz, 1978; Meece & Wigfield, 1990; Sparks, 2011; Woodard, 2004). Sian Beilock of the University of Chicago stated "People are very happy to say that they don't like math" (as cited in Sparks, 2011, p. 1). It is well known by the American public that few people actually enjoy studying mathematics, and hating it can be very contagious. Most of us are even expected to hate mathematics (Sembera & Hovis, 1990). The phenomenon of math hate and avoidance is likely to stem from the widespread math anxiety which is often developed in individuals at a young age.

Causes of Math Anxiety

Individuals begin studying numbers very early on in life with recognizing "how many" of something there is. As young children enter school, they begin learning more advanced concepts, and in some cases, develop math anxiety. Questioning the origins of this anxiety does not lead to an easy answer. Perhaps the best is, depends on the case. Professionals who have studied math anxiety have accepted that there is not one singular cause for it, but many (Erden & Akgül, 2010; Geist, 2010; Perry, 2004; Ruedy & Nirenberg, 1990; Stuart, 2000; Woodard, 2004).

Research has found that students don't begin experiencing symptoms of math anxiety until around fourth grade. A likely reason for the emergence of math anxiety is that as children get older, the mathematics they learn in school becomes more difficult (Geist, 2010; Jackson & Leffingwell, 1999; Ruedy & Nirenberg, 1990; Scarpello, 2007). It is when the mathematics becomes more difficult, that a fear of failure can develop in students. They can be humiliated to offer answers, and dread being asked questions on the spot. It is often that this fear develops after some negative experience. Fear of failure may alternatively develop out of lack of persistence, self-doubt, low self-esteem, shyness or intimidation (Woodard, 2004). Researchers and teachers agree that fear causes the hatred, avoidance, and anxiety of mathematics (Perry, 2004; Sembera & Hovis, 1990).

Another factor that is a possible cause for math anxiety that is related to the fear of failure, is an individuals' lack of confidence or having little *self-efficacy* (Cooper & Robinson, 1991; Stuart, 2000). Self-efficacy has been defined as "an individual's situation specific belief that he or she can successfully perform a behavior required to produce a given outcome" (Siegel, Galassi & Ware, 1985, p. 531). One study has found that mathematical self-efficacy is a stronger predictor of math anxiety than either having negative prior mathematics experiences, or gender factors (Pajares & Miller, 1994). Low self-esteem is related to having little mathematical self-efficacy. *Negative self talk* is associated with low self-esteem and has been proven to be strongly related to math anxiety (Hunsley, 1987; Lent, Brown & Larkin, 1984). Some examples of negative self talk include: "I'm dumb. Everyone is staring at me. They know I cannot understand this." (Sembera & Hovis, 1990, p. 21). Perhaps an even more destructive example of negative self talk is: “I knew this was going to happen. I can’t think. I feel I’ve forgotten everything I’ve learned” (Sembera & Hovis, 1990, p. 22). Making statements like these during a test situation can make the possibility of success very slim.

There are many factors which can decrease one’s confidence in their ability to perform in mathematics, thus becoming causes for math anxiety. Experiencing poor teaching may be considered at the top of the list. The article: *Predictive power of math anxiety and perceived social support from teacher for primary students’ mathematical achievement,* explains in detail how teachers contribute to students’ math anxiety from kindergarten through college (Erden & Akgül, 2010). The major behaviors teachers engage in which are included as causes of math anxiety are hostile behavior, modeling gender bias, having insensitive and uncaring attitudes, being angry towards students, setting unrealistic expectations, embarrassing students in front of peers, creating communication barriers, expressing dislike for the subject, and offering poor quality instruction (Jackson & Leffingwell, 1999). Teachers also serve as large support sources for students, and if they offer little to no support, students’ achievement is likely to suffer and anxiety can develop (Erden & Akgül, 2010).

Unfortunately, some students recall past mathematics experiences with teachers who they have perceived as “incredibly incompetent, or even malicious” (Perry, 2004, p. 322). Other research offers actions teachers take which increase anxiety in their students. For example, “Methods that emphasize the primacy of correct answers over concept development, competition and speed over understanding, and rote repetition over critical thinking will exacerbate the problems. Research has shown that these methods inherently create anxiety in children and adults” (Geist, 2010, p. 28). Aside from these negative behaviors, teachers may be a cause of math anxiety in their students by suffering from this anxiety themselves, and serve as carriers (Sloan, 2010).

Like teachers, an individual's family and peers are great forces of influence, and can become causes for math anxiety. Specifically, "Studies have shown that a mother's attitude and encouragement toward mathematics was a significantly more important factor to children having a positive attitude towards mathematics" (Geist, 2010, p.27). This researcher also mentions how the level of a parent's education can be linked to the level of their child's math anxiety. Without encouragement to be successful at mathematics, and having expectations to fail by parents, young children are likely to develop anxiety.

Myths about mathematics can also be considered causes for math anxiety. Sembera (1990) lists three big myths that exist about mathematics. These are: "You don't need math." "People who do well in mathematics have mathematical minds, and usually those people are male." and "If we fall behind, or if it has been a long time since we've studied mathematics, it's hopeless to try to learn it now." (pp. 12-16). All of these myths are de-bunked and if they are believed by mathematics students, anxiety can develop. Ruedy (1990) approaches mathematical myths in a different light. She explains how they are a part of a "cultural conspiracy" (p.41) and they are a great cause of math anxiety and the widespread hatred of the subject. This "conspiracy" is reinforced by parents, peers, media, and textbooks. Some of the myths she offers include "Math has to be approached with cold logic. There is a formula to be remembered for each problem. Math is for men. There is one best way to do each math problem" (p.41). Believing these different myths, can also create the math anxiety which has become epidemic in proportion.

When studying math anxiety, it is important to keep in mind how the causes of math anxiety in individuals, may stem from others' anxiety. Math anxiety can be thought of as a circular phenomenon. The causes create effects which may in turn be causes for the same anxiety within a person, or for individuals surrounding them, and it is highly contagious.

Effects of Math Anxiety

Perhaps the most obvious effect of math anxiety is a genuine hatred for the subject. As previously mentioned by Beilock, "People are very happy to say they don't like math" (as cited in Sparks, 2011, p.1). This hatred in its own right, can become a trigger in others' anxiety. In fact, many of the effects of math anxiety, also double as causes. This condition therefore can be considered as a widespread circular issue that needs treatment to break.

Worrying is a large component of anxiety, therefore of math anxiety. Morris, Kellaway & Smith (1978) showed that it is the worrying component of math anxiety which has the most profound effects on performance in the field of study. Worrying is likely to have this effect because it distracts one's mind from the task at hand, and thus decreases competency. Negative self-talk is a component of worry which is a cause and effect of math anxiety. Engaging in this talk, as a result of feeling anxious, only makes one feel worse, and perform worse.

Aside from the mentioned symptoms of anxiety, therefore of math anxiety, research has found an effect of anxiety on working memory. Ashcraft (2002) defines working memory as "the system for conscious, effortful mental processing" (p. 183). In his study, *Math anxiety: Personal, educational, and cognitive consequences* he observed how math anxiety had little effect on basic single digit operations, but with more complex arithmetic problems math anxiety showed greater effects. These problems were more difficult for those who suffered from math anxiety, and researchers interpreted that it was the conscious effort, or working memory that was required for success, but was however disrupted. Daniel Ansari, principal investigator of a Numerical Cognition Laboratory, said: “When engaged in mathematical problem solving, highly math-anxious individuals suffer from intrusive thoughts and ruminations…It’s very much as though individuals with math anxiety use up their brainpower they need for the problem” (as cited in Sparks, 2011, p.2). This disruption of working memory decreases achievement, and is a cause for greater math anxiety.

In addition, an individual who suffers from anxiety symptoms while engaged in mathematical tasks will dislike and avoid those situations at all costs, which makes it impossible for them to improve. This math avoidance is a common effect of math anxiety (Ashcraft, 2002; Bai, Wang, Pan, & Frey, 2009; Sparks, 2011). Math avoidance causes the anxious to enroll in less mathematics courses, when they may be academically capable. In a study done by Meece, Wigfield & Eccles (1990), it is evidenced that “only half of all high school graduates enroll in mathematics courses beyond 10th grade” (p. 60). This effect in turn causes less individuals to become mathematics majors in college, and choose math-related careers.

It has been found that “individuals with high levels of e anxiety do not have a global deficit in mathematical competence, and they can perform as well as their peers on whole number arithmetic problems” (Ashcraft, 2002, p. 182). It has been said that “Intimately connected with the underlying math deficiency is math anxiety” (Ruedy & Nirenberg, 1990, p. 9). As previously mentioned, anxiety restricts brain function and decreases mathematical competence in problems which require working memory. Many researchers have shown how suffering from math anxiety lowers achievement, which can reinforce the anxiety (Ashcraft, 2002; Bai, Wang, Pan, & Frey, 2009; Erden & Akgül, 2010; Meece, Wigfield & Eccles, 1990;

Morris, Kellaway & Smith, 1978). Ashcraft mentions about his subjects, “When the anxiety was relieved, a truer picture of their competence emerged” (2002, p. 183). In order to help individuals perform at their true potential, identifying existing math anxiety and implementing treatment is necessary.

Measuring Math Anxiety

Over the years, researchers have developed a few respectable scales for measuring math anxiety. The first formal scale was developed by Richardson & Suinn (1972) and is titled *The Mathematics Anxiety Rating Scale* (MARS). It contains 98 items of brief descriptions of mathematical situations that may arouse math anxiety while thought of by subjects taking the scale. Individuals respond to the scale by measuring their level of anxiety where 1 is assigned “not at all” anxious and 5 reflecting “very much” anxious. High scores on this scale reflect high levels of math anxiety suffered by the individual. The scale was designed for use in the research and treatment of math anxiety. It has been found to be highly reliable and strong evidence of validity has been found (Plake & Parker, 1982; Richardson & Suinn, 1972).

In 1982 researchers Plake and Parker analyzed the 98-item MARS, and made a revised scale, the MARS-R, Mathematics Anxiety Scale-Revised, which could alternatively be used. Items that were chosen from the original MARS were to meet the criteria of really measuring the anxiety, and to keep the length to approximately one-fourth of the original, which resulted in 24 items. Two factors were determined to be subscales of the MARS-R, where, “Factor 1 contained MARS items which pertained to learning, studying, or being tested over mathematics from a classroom perspective… the second factor contained items that dealt more with the day-to-day use of mathematical and computational concepts” (p. 552). Plake and Parker concluded from their research that "The revised MARS shows a pattern of relationships with measures of state… similar to that for the full scale MARS" (p. 556). The MARS-R is therefore a reliable test of math anxiety and is shown in Figure 2.

Figure 2. The Revised Mathematics Anxiety Rating Scale

MARS-R

Please rate each item in terms of how anxious you feel during the event specified. Use the following scale and record your answer in the space to the left of the item:

1 = Low anxiety
2 = Some anxiety
3 = Moderate anxiety
4 = Quite a bit of anxiety
5 = High anxiety

Learning Mathematics Anxiety

____ 1. Watching a teacher work an algebraic equation on the blackboard.
____ 2. Buying a math textbook.
____ 3. Reading and interpreting graphs or charts.
____ 4. Signing up for a course in statistics.
____ 5. Listening to another student explain a math formula.
____ 6. Walking into a math class.
____ 7. Looking through the pages in a math text.
____ 8. Starting a new chapter in a math book.
____ 9. Walking on campus and thinking about a math course.
____ 10. Picking up a math textbook to begin working on a homework assignment.
____ 11. Reading the word "statistics."
____ 12. Working on an abstract mathematical problem, such as: "if x = outstanding bills, and y = total income, calculate how much you have left for recreational expenditures."
____ 13. Reading a formula in chemistry.
____ 14. Listening to a lecture in a math class.
____ 15. Having to use the tables in the back of a math book.
____ 16. Being told how to interpret probability statements.

Mathematics Evaluation Anxiety

____ 1. Being given a homework assignment of many difficult problems which is due the next class meeting.
____ 2. Thinking about an upcoming math test one day before.
____ 3. Solving square root problem.
____ 4. Taking an examination (quiz) in a math course.
____ 5. Getting ready to study for a math test.
____ 6. Being given a "pop" quiz in a math class.
____ 7. Waiting to get a math test returned in which you expected to do well.
____ 8. Taking an examination (final) in a math course.

As seen in the figure, directions are for students to rate each item involving a mathematical situation in terms of how anxious they feel during those events. The two subscales, Learning Mathematics Anxiety and Mathematics Evaluation Anxiety are given. This scale does not however include daily life situations, which as previously mentioned, can elicit anxiety in students.

Another widely used scale for measuring math anxiety is the *Fennema-Sherman Mathematics Attitude Scales* (1976). This scale is "intended to assess feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (Rounds & Hendel, 1980, p. 139). The full set of math attitude scales can be purchased from the American Psychological Association, but an adaption of the complete scale can be found in an appendix of Tobias (1993), and is shown below in Figure 3.

Figure 3. The Fennema-Sherman Mathematics Attitude Scales

Composite Math Anxiety Scale*

For each statement, give a number 1–5 which indicates whether you strongly agree (1) or strongly disagree (5).

I usually have been at ease in math classes.
I see mathematics as a subject I will rarely use.
I'm no good in math.
People would think I was some kind of a grind if I got A's in math.
Generally, I have felt secure about attempting mathematics.
I'll need mathematics for my future work.
I'd be happy to get good grades in math.
I don't think I could do advanced mathematics.
It wouldn't bother me at all to take more math courses.
For some reason, even though I study, math seems unusually hard for me.
I will use mathematics in many ways as an adult.
It would make people like me less if I were a really good math student.
My mind goes blank and I am unable to think clearly when working in mathematics.
Knowing mathematics will help me earn a living.
If I got the highest grade in math, I'd prefer no one knew.
Math has been my worst subject.
I think I could handle more difficult mathematics.
Winning a prize in mathematics would make me feel unpleasantly conspicuous.
I'm not the type to do well in math.
Math doesn't scare me at all.

The format of the Fennema-Sherman anxiety scale is different than the MARS and MARS-R. Instead of having individuals rate their level of anxiety in a variety of situations, individuals are asked to agree or disagree with a variety of statements about mathematics.

Another less formal approach to testing for math anxiety is offered by Ruedy & Nirenberg (1990). She created her own scale to assess one's level of math anxiety in preparation for treating it. This scale is given in yes/no format, with the answer depending on the person's feelings. A subset of this scale, titled: *The Daily Grind: Your Job* is shown in Figure 3. Other sub sections include headings of "Childhood", "Self-Image", "Learning Experience", "Hearth and Home", "Family Ties", and "Shopping". These headings illude to her beliefs that math anxiety exists in many areas of an individual's life, and by idetifying where problems exist, one can learn how to cope with the anxiety and become successful and confident in addressing mathematical problems.

Figure 4. Ruedy & Nirenberg, Math Anxiety Scale: How does math affect your life?

THE DAILY GRIND: YOUR JOB

1. Have you passed up opportunities in order to avoid working with numbers and machines (computers)? ___ ___
2. Do you think knowing math will water down your creative talents and other skills? ___ ___
3. Do you feel stupid doing math in front of your boss or colleagues? ___ ___
4. If you solve a problem correctly, do you still feel like a fraud, asking yourself, ''What about next time?'' ___ ___
5. Do you leave memos unread if they contain statistics or a graph (or just a bunch of annoying numbers)? ___ ___
6. Do you worry about the horrible moment when you will be found out? ___ ___
7. Do you pretend to know math you don't understand? ___ ___
8. Do you leave the room when people discuss union business, pay raises, fringe benefits? ___ ___
9. Do you put off billing and other jobs involving numbers? ___ ___

The math anxiety measure format of the MARS-R and Fennema-Sherman scales have been found to be highly reliable (Bai, Wang, Pan, & Frey, 2009). In developing a math anxiety scale which can be used for research, both formats will be used. It can be thought of as highly benefical to identify ways in which students see themselves as anxious as well as identifying their individual feelings regarding mathematics.

Knowing the reasons for studying math anxiety, the causes and effects of it, as well as the existing methods of measuring it, is relevant prior to future studies in math anxiety. As noted in this literature review, math avoidance and math hate exists in great proportion in the United States. Mathematics educatiors need to do their part in reducing it in their own classrooms and communities in order to help this country compete in the technologically advanced global economy.

Experimental Design and Data Collection

This experiment was designed to test the dual hypotheses that non-mathematics major college students would score higher on an anxiety rating scale compared to their peers who are enrolled as mathematics majors, and that those who consider themselves to be math anxious, attribute their anxiety to having negative past experiences in a mathematics classroom. To test the first part of the hypothesis, a *The Gulick Math Anxiety Scale* (G-MAS) was given to both subgroups of students, mathematics majors and non-mathematics majors. Quantitative data was analyzed to determine what differences in math anxiety, if any, exist among the participants. To test the second part of the hypothesis, students were asked to report their level of math anxiety, and offer reason for why they believe this anxiety exists, giving qualitative data.

Participants

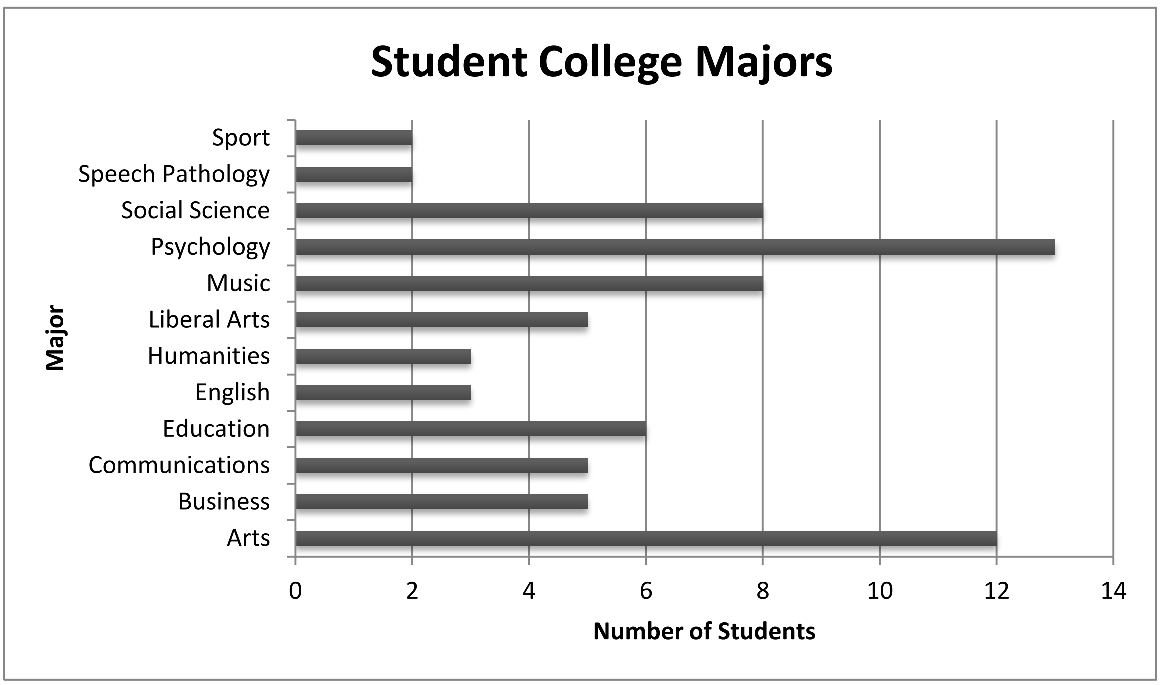
This study was conducted at a 4-year Liberal arts University in the Northeast United States. The participants in this study were students enrolled at this university, and taking the following mathematics courses: Mathematics in Action (MATH 110), to make up the non-mathematics major group, or University Calculus 1 (MATH 122) and Mathematical Structure and Proof (MATH 210) which made up the mainly mathematics major group. Students from the Mathematics in Action course are described in the figure below:

Figure 5. Participant Demographics from MATH 110, n=72

	Male	Female
Freshman	18	33
Sophomore	2	7
Junior	5	3
Senior	1	3
Total	26	46

Mathematics in Action is a course designed to fulfill the mathematics requirement in the College Core Curriculum needed for a Bachelor's degree. Students in this course are assumed to have a background including at least the N.Y.S. Algebra II Trigonometry class or equivalent. These students were from a wide variety of majors ranging from Communications to History, although there were no mathematics majors.

Figure 6. Participant Majors in MATH 110, n=72



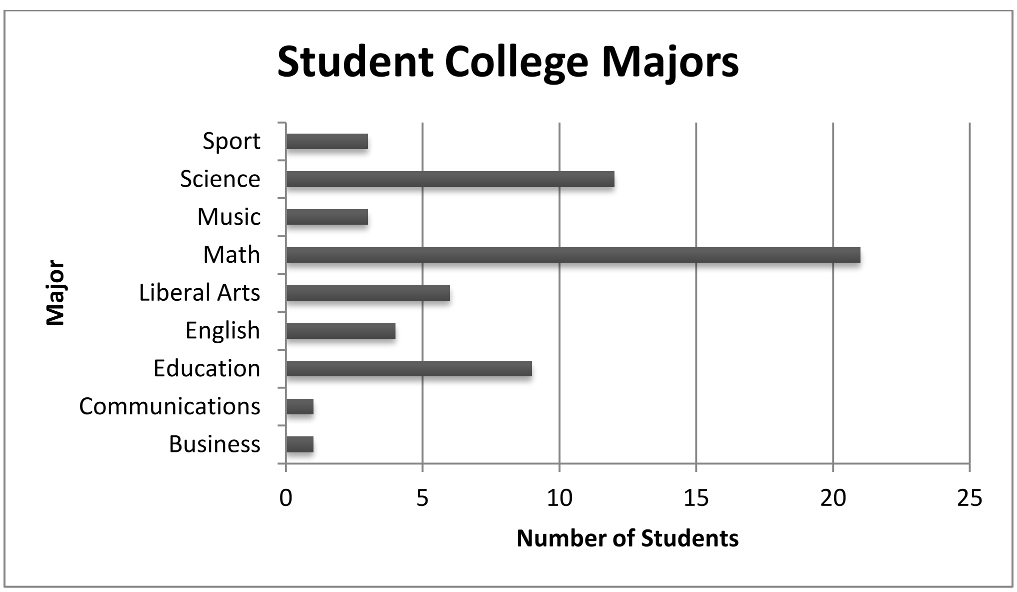
MATH 122 is a 4-credit Calculus 1 course, while MATH 210, a 3-credit course mainly for mathematics majors which has a prerequisite of Calculus 2, and is the prerequisite for many upper level mathematics courses. Participant data from students in these two courses are given in Figures 7 and 8 below.

Figure 7. Participant Demographics from MATH 122 and MATH 210, n=60

	Male	Female
Freshman	12	8
Sophomore	6	12
Junior	5	11
Senior	3	3
Total	26	34

Student majors that encompass the two classes are shown in the table below. Although there is some variability, they make up the mathematics and science major population in the study.

Figure 8. Participant Majors from Math 122 and MATH 210, n=60



Design

This experiment was conducted to determine the differences in the levels of math anxiety that exists among subgroups of college students. Furthermore, students' reasons for why their reported level of math anxiety exists was evaluated qualitatively. Subjects were given the *Gulick Math Anxiety Scale*, G-MAS which was developed by the researcher, and is explained in detail in the following section: Instrument items and justification of items. The purpose of this scale is to determine the level of math anxiety that exists in individuals. Participant responses were statistically analyzed to address the first part of the hypothesis in this study. After completing the scale, students were given the opportunity to report their level of math anxiety from non-existent to severe, and then offer a reason for why they believe this anxiety exists (or does not) in 10 words or less. This second portion addresses the second part of the research hypothesis.

Instrument Items and Justification of Items

As mentioned previously in the literature review, researchers have been studying math anxiety and developing scales to measure it for the past few decades. The anxiety scale used in this study has two main sections, 15 questions total, with part 1 containing 8 questions, and part 2 containing 7. The first component of the scale is based on the highly regarded *Mathematics Anxiety Rating Scale-Revised* (MARS-R) which was developed in 1982 by Plake and Parker. This portion of the scale requires students to identify how anxious they would feel in a variety of situations involving mathematics. The options for level of anxiety include: (1) low anxiety (2) some anxiety (3) moderate anxiety (4) quite a bit of anxiety and (5) high anxiety. In this section of the scale, the 8 questions are shown in Figure 9 on the following page.

Figure 9. Questions 1-8 from the *Gulick Math Anxiety Scale*

1. Watching a teacher solve an algebraic equation on a board
2. Looking through pages in a math book
3. Being asked to add 976 and 777 in your head
4. Thinking about taking a math test
5. Determining the amount of change you should get back from a purchase involving several items
6. Calculating a tip at a restaurant without using a calculator
7. Having someone explain bank interest rates as you decide on a savings account
8. Being asked by a friend to answer the question: How long will it take to get to New York City if I drive 70 miles per hour?

Research has found that math anxiety is multidimensional, that is, it can exist as feelings of pressure, fear, inadequacy, and hatred, in a variety of academic and ordinary life situations. For this purpose, this portion of the scale involves mathematical situations in a variety of both academic and real-life contexts. Question #1: "Watching a teacher solve an algebraic equation on a board" gauges the level of anxiety a student feels during a mathematics class, while watching a teacher demonstrate mathematical procedures. This question is relevant, as math anxiety is surely to be felt in a mathematics class for those who suffer from it. Question #2: "Looking through pages in a math book" forces students to imagine themselves looking through a mathematics textbook, at a variety of topics, procedures, and theorems. This situation is likely to elicit anxiety from those who have math anxiety due to the subject itself.

Question #3: "Being asked to add up 976 and 777 in your head" elicits math anxiety from those who have it due to a feeling of pressure and a fear of failure, as well as anxiety from the simple sight of numbers and basic computations. As explained in the literature review, feelings of pressure and fear of failure are large components of math anxiety. Question #4: "Thinking about taking a math test" relates math anxiety to test anxiety, which can be closely related. It is possible that this may be the most commonly reported "high anxiety" category due to the high level of pressure and again, fear of failure.

As math anxiety is believed to exist in real life contexts, outside academia, Question #5: "Determining the amount of change you should get back from a purchase involving several items" has students imagine themselves in an ordinary life situation which would cause anxiety for those who suffer from it. This anxiety may come from a fear of embarrassment of obtaining a wrong answer or simply manipulating numbers. Question #6: "Calculating a tip at a restaurant without using a calculator" is similar to question #5, but perhaps involves more mathematical thought. Because individuals have become so accustomed to using "tip-calculators" on cell phones, the thought of having to figure a tip without one may be very anxiety provoking from those who suffer from math anxiety. Question #7: "Having someone explain bank interest rates as you decide on a savings account" gauges the level of math anxiety due to, the mere sight or thought of numbers and how they are interpreted in real life. Individuals who suffer from math anxiety would find this scenario especially anxiety provoking because it is relevant to their lives, however, they may not be able to fully understand the mathematical concepts involving interest rates. Question #8: "Being asked by a friend to answer the question: How long will it take to get to New York City if I drive 70 miles per hour?" is another everyday situation question, which involves pressure from peers to know the "right answer".

The eight items included on the first portion of the scale are likely to range in the level of math anxiety that they identify. The highest anxiety scores were likely to be exhibited by question 3: "Being asked to add up 976 and 777 in your head" and question 5: "Determining the amount of change you should get back from a purchase involving several items". The reason for this premonition is that these are the most basic instances involving mathematics. A participant rating their feelings as "highly anxious" in these situations will be likely to suffer from the highest level of math anxiety. On the other hand, it is likely that question 4 "Thinking of taking a math test" was likely to receive more "anxious" responses than all others due to the possible association with test anxiety.

The second part of the G-MAS uses a different kind of Likert scale. Researchers have developed different but still effective scales for measuring math anxiety such as Aiken and Dreger (1963) and Fennema, Sherman (1976). These instruments include statements about mathematics and feelings associated with the discipline, and then have individuals decide if they (1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree or (5) Strongly Agree with each statement. Some items on these scales are worded negatively, which demonstrate the dislike and anxiety towards the subject, while some are positively worded. In terms of scoring, these positively stated items were reversed in order to conclude with accurate results. Questions in the anxiety scale used in this study are shown in the Figure below, and come from the above mentioned anxiety scales.

Figure 10. Questions 9-15 of *Gulick Math Anxiety Scale*

9. Mathematics makes me feel nervous
10. I worry about my ability to solve mathematics problems
11. I find mathematics interesting and useful
12. I get uptight during math tests
13. My mind goes blank, and I am unable to think clearly when working with math
14. I would like to take more math classes
15. The feeling I have towards mathematics is a good feeling

Contrary to the first part of the anxiety scale, these statements identify the attitudes towards mathematics held by students, instead of how anxious they felt in given situations. Testing for both of these components is beneficial and relevant. Question #9: "Mathematics makes me feel nervous" tests for perhaps the most basic component of math anxiety, nervousness towards the subject. Question #10: "I worry about my ability to solve mathematics problems" gauges student confidence in their ability to solve math problems. Those who suffer from math anxiety have very low confidence in the subject, which this question is asking them to identify about themselves. Question #11: “I find mathematics interesting and useful” is the first positively stated item in this assessment. This question was be reversed for scoring purposes and is relevant because those who suffer from math anxiety do not see mathematics as a tool which is useful and interesting, but instead as a discipline studied by only a small number of people.

Question #12: “I get uptight during math tests” tests for the math anxiety associated with testing anxiety in terms of pressure and fear of failure. Question #13: “My mind goes blank, and I am unable to think clearly when working with math” is a direct test of math anxiety, as it causes cognitive interference for those who suffer from it. All they can think about while working with mathematics are the negative thoughts about how they cannot be successful and they forget all they have learned. Question #14: “I would like to take more math classes” is another positively worded question which was reversed for scoring. Students who suffer from math anxiety also have a sense of math avoidance, they will not take math classes unless they have to, and this question identifies that avoidance. The final question #15: “The feeling I have towards mathematics is a good feeling” is positively stated, therefore reversed for scoring, and asks students to identify if they feel good about mathematics, those who suffer from math anxiety of course, would not.

The third and final component of the instrument used in this study has subjects report tthe level of math anxiety they feel they suffer from using the choices (1) no math anxiety (2) low math anxiety (3) moderate math anxiety (4) high math anxiety and (5) severe math anxiety. Then, on lines below subjects are asked to give a brief reason (10 words or less) for why they believe they have this level of math anxiety. This part of the scale addresses the final part of the hypothesis of this study, which states that students who suffer from math anxiety attribute having it due to a negative past experience in a mathematics classroom.

Data Collection

Data collected in this study comes from the G-MAS and will be used to address both components of the hypothesis. The first statement, comparing the anxiety between college mathematics majors and non-mathematics majors was quantitatively analyzed using data from parts 1 and 2 of the anxiety scale. The highest level of anxiety was determined by questions 3 and 5, due to what was previously mentioned. Results given for each question however, were analyzed and compared between each of the subgroups to determine the differences in the levels of math anxiety that exist.

The second part of the hypothesis was tested by part 3 of the anxiety scale. Participants who reported having moderate, high, and severe math anxiety had their responses for why they have that anxiety coded and compared to determine what factor, or past experience they feel causes that anxiety they have. The most commonly given reason for math anxiety was determined and compared to the hypothesis statement, which states that most students will attribute math anxiety to having negative past experiences in a mathematics class.

Methods of Data Analysis

This study was mainly quantitative in nature, as it compared scores on a Likert scale to determine levels of math anxiety present among college students. Participant mean scores on the G-MAS were the basis of analysis on students' math anxiety. Comparing means allowed for analysis on the differences between classes, majors, sex, ethnicity, and college status. Both descriptive and inferential statistics used in these comparisons as mean scores were compared and two sample T-tests were employed to determine the level of significance of the differences in scores. In addition, qualitative data was generated by students' written explanation for their believed level of math anxiety and was coded by similar responses, and percentages of those responses were analyzed. Data that was collected from the G-MAS was coded and organized into a Microsoft Excel file and a screenshot can be found in Appendix C. After it was organized, it was analyzed by Minitab statistical software.

Analysis of Students' Level of Math Anxiety

The G-MAS contained 15 questions, with the first 8 requiring students to state how anxious they feel in a variety of mathematical situations based on a five point "no anxiety" to a "severe anxiety" Likert scale. The responses were coded by number as following, (1) no math anxiety, (2) low math anxiety, (3) moderate math anxiety, (4) high math anxiety, and (5) severe math anxiety. The second part of this scale included the remaining 7 questions which had students rate their feelings on given statements regarding mathematics. This scale was coded from 1 "strongly disagree" to a 5, which corresponded to "strongly agree". Three questions on this portion of the scale were positively worded, namely question11: "I find mathematics interesting and useful", question 14: "I would like to take more math classes" and question 15:

"The feeling I have towards math is a good feeling". For analysis, responses to those questions were reversed to illustrate the negative feelings regarding mathematics. This quantitative data was examined through an analysis of variance (ANOVA) to determine significance at the 0.05 level.

Analysis of the Dimensions of Math Anxiety

All of the 15 questions on this anxiety scale were coded into one of the following four dimensions: Everyday, Math Course, Test, and Attitude. These categories reflect each dimension of mathematics in which students may encounter symptoms of math anxiety. The purpose of this coding was to analyze which aspect of mathematics makes students the most anxious. Means of these dimensions were analyzed and compared from the data of all subjects that were included.

Analysis of Students Perceived Causes for Math Anxiety

After students reported their perceived level of math anxiety, they were asked to give a reason for why they believe that level was held by them. Since the purpose of this section was to see the reasons for why anxiety exists, responses only given by those students who rated themselves as having moderate, high, or severe math anxiety were examined. Those responses were coded into categories based on similarity. Seventy-seven student responses were coded and were separated by the classes in which the students were enrolled. Forty-five of these students were in MATH 110, while the remaining 32 were from the MATH 122 or MATH 210 group, giving a sample proportion of students reporting moderate, high, or severe math anxiety of 58%. The most common responses were examined, as well as the differences in the responses between both groups of students.

Results

The collection of quantitative data that included students' ratings on particular questions regarding math anxiety, their stated believed level of math anxiety, as well as a qualitative reason for why they believe that level exists, produced many results. Some of these results, which are given below, were expected and may be considered obvious, while others may not be.

- ***Non-mathematics majors scored significantly higher on the Gulick Math Anxiety Scale compared to mathematics majors, p-value 0.000***: Students' responses to the 15 questions on this anxiety scale were analyzed using ANOVA at the 0.05 significance level. The mean score for non-mathematics majors was 2.695, and 2.423 for mathematics majors. Although both of those scores lie in the "Some Anxiety" range, the non-mathematics major group was statistically significantly closer to reporting "Moderate Anxiety".

- ***Math anxiety found to exist in the highest level when associated with testing anxiety p-value 0.000:*** The 15 questions on this anxiety scale were classified by dimension of mathematics. Those dimensions included Math Course, Everyday, Test, and Attitude. Analysis of these questions, after coded by dimension were analyzed. The mean score for the Test dimension was 3.280, Attitude mean= 2.674, Math Course mean= 2.277, Everyday mean= 2.005.

- ***The main reason to report math anxiety is having a lack of confidence:*** After qualitative data was collected, it was categorized into groupings of similar responses. Descriptive statistics were used, and the percentages of responses students gave for their reported level of anxiety were compared. The highest percentage was for the statement "I'm bad at math" which 33.3% of the math anxious 110 reported.

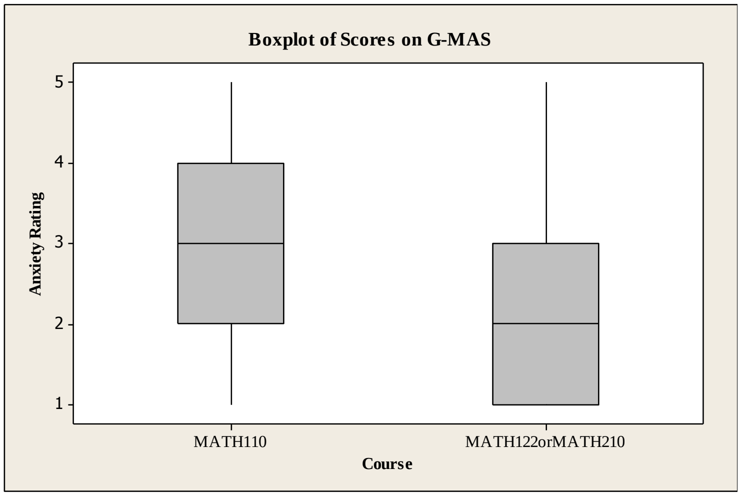
The three results stated above were all found by analysis of participant responses to the G-MAS, and are described in detail below.

Result 1: Non-mathematics majors scored significantly higher on the *Gulick Math Anxiety Scale* compared to mathematics majors

An analysis of both students' reported math anxiety, as well as the math anxiety level found to exist by the scale in this research yielded multiple results. The prevalence, and distribution of math anxiety that exists among these sub-groups of college students was evident after participant completion of the instrument. Participant demographics such as college status, sex, ethnicity, and major were collected. The hypothesis of the research was that students enrolled in MATH 110 would score higher on the G-MAS compared to their peers enrolled in MATH 122 or MATH 210. The null hypothesis was rejected, as significance was found between both the student's self-rating, and the anxiety which was found to exist by the anxiety scale itself.

Firstly, a one-way ANOVA revealed that students in MATH 110 scored statistically significantly higher on the rating scale parts 1 and 2 (mean= 2.737) compared to the students in MATH 122 or 210 (mean= 2.334). Discussed means include all 15 questions on the scale. A box plot of the scores from students is shown on the following page in Figure 11.

Figure 11. Boxplot of students' ratings on G-MAS



In addition to the previously mentioned differences between anxiety levels of these subgroups of students, other notable differences emerged. Females scored significantly higher (mean= 2.983) on this math anxiety scale compared to their male peers (mean= 2.612), p-value 0.011.

Differences in the math anxiety among college majors were found. Students who are non-mathematics majors scored higher (mean=2.693) than those students who identified themselves as mathematics majors (mean=2.423). Although there were only 21 mathematics majors compared to 111 non-mathematics students, this is still a significant result. It is possible that the constant exposure and dedication that are required to be a mathematics major in itself reduces math anxiety in students. Of all majors listed, those who identified themselves as Liberal Arts (undeclared major) students had the highest mean anxiety level of 2.993, compared to the lowest which were the students whose major was one of the natural sciences, with mean of 1.640. Other results are listed in Figure 12 on the following page. The number of students included in each major can be found in the experimental design section in Figures 6 and 8. Although some of group sample sizes are small, an examination of anxiety levels in majors has brought up interesting results.

Figure 12. Mean Anxiety Scores by Major

Major	Mean Anxiety Score
Liberal Arts	2.993
Speech	2.960
Humanities	2.826
English	2.815
Education	2.768
Math	2.675
Arts	2.625

Major	Mean Anxiety Score
Music	2.527
Sport	2.502
Communications	2.418
Social Sciences	2.368
Business	2.340
Psychology	2.314
Science	1.640

The discussed ratings in Result 1 were those that were given using 15 questions on the math anxiety scale (parts 1&2). The students self-reported anxiety ratings were mainly used in result 3, where the reported anxiety level was given with a reason for why it was thought to exist.

Result 2: Math anxiety exists in the highest level when associated with testing anxiety

The 15 questions were statistically analyzed in a variety of ways. First, questions were categorized by four dimensions. Questions 1,2 and 14 represented the dimension “Math Course” which involved scenarios regarding taking or thinking about a mathematics course. The dimension “Everyday” was represented by questions 3,5,6,7 and 8. These questions gauged how math anxious students felt in everyday mathematical situations. Questions 4 and 12 were included in the dimension of “Test” which asked students to think about their feelings regarding mathematics tests. The fourth dimension, “Attitude” was represented by questions 9,10,11,13 and 15. These questions asked students to respond about their feelings towards mathematics.

An analysis of variance was conducted at the 0.05 significance level to determine which dimension of math anxiety was the highest. All four dimensions revealed statistically significant responses. It was found that the testing dimension received the highest reported math anxiety with a mean of 3.280. Question 12 “I get uptight during math tests” had the highest mean of 3.367, which corresponds to borderline “Undecided and Agree”. The other test question number 4 “Thinking about taking a math test” had a mean of 3.193, which was the second highest rated. The principal researcher believed that the questions that would elicit anxiety in the most anxious individuals were questions 3 and 5. As seen in Figure 13 on the following page, students in MATH 110 scored higher on both of those questions, compared to their peers in MATH 122 or MATH 210, hinting that students in MATH 110 suffer from having the severest math anxiety.

Similar analysis revealed that the next highest anxiety dimension was the attitude dimension with a mean of 2.673. Questions encompassed in this dimension were included on the second portion of the G-MAS where students agreed or disagreed with statements about mathematics. This finding shows that students have negative attitudes regarding mathematics, and do not have good feelings about the discipline. The highest rated question in this dimension was 10, “I worry about my ability to solve mathematics problems”. This result eludes to students’ low confidence with their ability to be successful at mathematics, and this result is confirmed in result 3 as well.

Student responses on the G-MAS are given as percentages for both subsets of classes and given in Figures 13 and 14 on the following page.

Figure 13. Percentages of Responses on questions 1-8

Dimension		Math 110 or Math 110,210	Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a bit of Anxiety	High Anxiety
Math Course	1. Watching a teacher work an algebraic equation on a board	110	58.33%	22.22%	11.11%	4.17%	4.17%
		122/210	65.00%	16.67%	16.67%	1.67%	0.00%
Math Course	2. Looking through pages in a math book	110	51.39%	20.83%	16.67%	8.33%	2.78%
		122/210	26.67%	26.67%	30.00%	13.33%	3.33%
Everyday	3. Being asked to add up 976 and 777 in your head	110	37.50%	27.78%	18.06%	12.50%	4.17%
		122/210	43.33%	35.00%	18.33%	1.67%	1.67%
Test	4. Thinking about taking a math test	110	8.33%	26.39%	25.00%	16.67%	23.61%
		122/210	1.67%	23.33%	26.67%	31.67%	16.67%
Everyday	5. Determining the amount of change you should get back from a purchase involving several items	110	46.48%	21.13%	21.13%	7.04%	4.23%
		122/210	53.33%	28.33%	8.33%	5.00%	0.00%
Everyday	6. Calculating a tip at a restaurant without using a calculator	110	55.56%	26.39%	12.50%	5.56%	0.00%
		122/210	58.33%	28.33%	8.33%	5.00%	0.00%
Everyday	7. Having someone explain bank interest rates as you decide on a savings account	110	11.11%	33.33%	26.39%	15.28%	13.89%
		122/210	15.00%	30.00%	30.00%	15.00%	10.00%
Everyday	8. Being asked by a friend to answer the question: How long will it take to get to New York City if I drive 70 miles per hour?	110	29.17%	29.17%	18.06%	12.50%	11.11%
		122/210	38.33%	38.33%	20.00%	3.33%	0.00%

Figure 14. Percentages of Responses on questions 9-15

Dimension		Math 110 or Math 110,210	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Attitude	9. Mathematics makes me feel nervous	110	19.44%	22.22%	18.06%	26.39%	13.89%
		122/210	10.00%	45.00%	30.00%	15.00%	0.00%
Attitude	10. I worry about my ability to solve mathematics problems	110	16.67%	26.39%	9.72%	33.33%	13.89%
		122/210	10.00%	30.00%	25.00%	33.33%	1.67%
Attitude	11. I find mathematics interesting and useful	110	15.28%	16.67%	31.94%	34.72% %	1.39%
		122/210	0.00%	3.33%	3.33%	61.67%	31.67%
Test	12. I get uptight during math tests	110	6.94%	26.39%	13.89%	25.00%	27.78%
		122/210	3.33%	21.67%	15.00%	38.33%	21.67%
Attitude	13. My mind goes blank, and I am unable to think clearly when working with math	110	12.50%	34.72%	15.28%	16.67%	20.83%
		122/210	16.67%	48.33%	13.33%	16.67%	5.00%
Math Course	14. I would like to take more math classes	110	41.67%	18.06%	29.17%	8.33%	2.78%
		122/210	8.33%	5.00%	40.00%	40.00%	6.67%
Attitude	15. The feeling I have towards mathematics is a good feeling	110	30.56%	16.67%	31.94%	15.28%	5.56%
		122/210	11.67%	61.67%	21.67%	5.00%	0.00%

Figures 13 and 14 highlight the percentages of the responses of all students on the given anxiety scale. The differences in responses between both sub-groups of classes are shown by the percentages. The higher ratings for the MATH 110 students provided the initial result, and the dimension percentages provide the result that math anxiety exists most often when associated with testing. Graphs showing the data in Figures 13 and 14 can be found in Appendix C.

Result 3: The primary reason for math anxiety is having a lack of confidence

Part 3 of the G-MAS asked students to rate their own level of math anxiety they thought they had, and then give a reason for why that level of anxiety exists. Responses from students who responded as having either moderate, high, or severe levels of math anxiety are illustrated on this page, and the following page in the figures which are separated by course.

Figure 15. Responses from students in MATH110 n=45

	Participant Self-Reported Anxiety			
Reason for Math Anxiety	Moderate Anxiety	High Anxiety	Severe Anxiety	Total
"I get nervous during tests"	3 6.7%	1 2.2%	1 2.2%	5 11.1%
"I've never enjoyed math"	2 4.4%	1 2.2%	0 0%	3 6.7%
"I don't like word problems"	2 4.4%	0 0%	0 0%	2 4.4%
"Math is Difficult/Frustrating"	5 11.1%	3 6.7%	0 0%	8 17.8%
"I have a weak foundation in math"	2 4.4%	1 2.2%	1 2.2%	4 8.9%
"I'm bad at math"	6 13.3%	5 11.1%	4 4.4%	15 33.3%
"I'm not confident or am scared of failing"	6 13.3%	2 4.4%	0 0%	8 17.8%

Figure 16. Responses from students in MATH 122 or MATH 210 n=32

	Participants Self-Reported Anxiety			
Reason for Math Anxiety	Moderate Anxiety	High Anxiety	Severe Anxiety	Total
"I get nervous during tests"	5 15.6%	3 9.4%	0 0%	8 25%
"I've never enjoyed math"	2 6.25%	0 0%	0 0%	2 6.25%
"I don't like word problems"	0 0%	0 0%	0 0%	0 0%
"Math is Difficult/Frustrating"	5 15.6%	1 3.125%	0 0%	6 18.75%
"I have a weak foundation in math"	4 12.5%	0 0%	0 0%	4 12.5%
"I'm bad at math"	0 0%	0 0%	0 0%	0 0%
"I'm not confident or am scared of failing"	12 37.5%	0 0%	0 0%	12 37.5%

As seen in Figures 15 and 16, the highest responses, #1 and #2 respectively are from the last two categories "I'm bad at math" and "I'm not confident or am scared of failing". These both can be summarized as having a lack of confidence. Fear of failure is a natural human condition, and the difficulty of mathematics may increase that fear. Past failures lower students' confidence, cause them to avoid studying the subject, and therefore may lead to future failures. These findings accept the null hypothesis, as it can be seen that the response "I have a weak foundation in math" is closest to the hypothesis "I have had a negative past experience in math", received little response.

It can also be observed in Figure 16 that no MATH 122 or MATH 210 students rated themselves as having "severe" math anxiety, the majority, rated themselves has having "moderate" math anxiety. This result compares to student responses in Figure 15 where 6 students rated themselves as having "severe" math anxiety.

In summary, the participants' reported levels of math anxiety among sub-groups of college students exist in varying severity, and prevalence. The result that non-mathematics major students reported higher levels of math anxiety may be obvious, however the reasons for that said anxiety may not be. The distribution of reported anxiety levels by the G-MAS based on major prompts the thought of what it could be about the major, the courses (or lack there of), or future occupation which could be associated with math anxiety.

Implications for Teaching

The hypothesis for this research study was that students enrolled in non-major mathematics courses in college would score higher on a mathematics anxiety rating scale compared to their peers who were enrolled in mathematics courses for mostly mathematics majors. Further, it was hypothesized that students who identify themselves as having medium to high levels of anxiety on a survey attribute it to having a negative past experience in a mathematics class. The results of this study concluded that a student's major was a greater predictor of their anxiety level compared to the course they were enrolled in. The previously discussed results lead to three clear implications for teaching that are discussed in this section. Further, suggestions for further research are discussed.

Classroom Implications

The implications for classroom instruction can be generalized to all mathematics courses and come directly from the results obtained in this research. They are all possible ways to decrease math anxiety in students, and therefore promote a more positive view of mathematics for students.

- ***Keep in mind the students' common anxiety over assessments, and use strategies for relieving that anxiety.***
- ***Emphasize to students that success in mathematics takes hard work and practice.***
- ***Give students many opportunities to prove what they know, to reduce the fear of failure and to increase students' confidence.***

Implication 1: Teachers should keep in mind the students' common anxiety over assessments, and use strategies for relieving that anxiety.

It is well known by the general public, and especially by educators that the examinations given to students during almost every year of their student careers are overwhelming for them. The pressure associated with these exams is made worse by parents, teachers, peers, and administrators. Students must do well in middle school to be successful in high school, and successful in high school to get into college, where they will be faced with only more assessments. Because of the high stakes students face when they sit down at every exam, anxiety easily develops. It is a natural human condition to fear failure, which is a common experience for many students. This is most definitely the case for mathematics exams. Students often worry about getting the "right answer" and believe there is only one correct way of doing mathematics. It has been reported in this research that when thinking of or while taking tests, students suffer from the highest levels of math anxiety. Teachers can help students relieve this anxiety by first becoming aware that it exists. They should also then become fluent in the strategies that help reduce testing anxiety in students. These strategies include: teaching good study habits such as study groups, showing students ways to help remember content like using mnemonics, givng students practice examinations, reminding students to relax during tests, and help them engage in positive self talk.

Implication 2: Emphasize to students that success in mathematics takes hard work and practice.

It is common knowledge among mathematicians that their success at mathematics has been mostly due to hard work. Many hours are spent studying, and practicing mathematics problems and reviewing solutions. Group collaboration is also a major component of having success in mathematics. Teaching and working with others on problems is great practice for mathematics. Teachers should make sure that they stress these ideas to their students. They can discuss their own personal struggles and experience with the discipline to make these ideas concrete for their students. In addition, teachers should encourage students to work hard, and when they do, they should be praised.

Implication 3: Give students many opportunities to prove what they know, to reduce the fear of failure and to increase students' confidence.

By giving students many opportunities to show what they know, mastery can be emphasized, and students' confidence can be increased. If students fail at something the first time, giving them opportunities to try again will take off the pressure of having to have it correct the first time, and they will have more practice. This idea goes along with the idea that if students fail at something, what they do after they fail is often more important than receiving one poor grade. Students always have the opportunity to be successful, as long as they have the will and dedication to work hard. When students have accomplishments, they should receive positive reinforcement for the hard work that got them there. These teacher practices should help reduce students' fears and boost their confidence in their own abilities in mathematics.

Suggestions for Future Research

This research has illustrated the significance of math anxiety in education, and it should be recognized by all mathematics teachers, as they are the ones who have the best opportunity to reduce it. There are factors which, if this research was done again, could be done differently to produce stronger results. The *Gulick Math Anxiety Scale* was successful at determining which dimensions of math anxiety exists in the severest degree in students, but could have included a wider variety of questions.

- ***Suggestion 1: Include more questions on the anxiety scale.*** The two questions that were categorized in the "test" dimension, both alluded to the idea of the "math test" however, a better discrimination of the general "testing anxiety" would have been beneficial. More questions regarding the math class would show more specifically what it is about math classes that give students anxiety, compared to what was given. These questions could have taken the place of the several real life "everyday" dimension anxiety questions.
- ***Suggestion 2: Include a sample with more mathematics majors.*** The sample included in this study was fairly representative of a college community, but not entirely representative of mathematics majors. Including more mathematics students in the sample would have allowed for possibly greater differences in the math anxiety found to exist in that sample. Aside from the college community, math anxiety that exists in younger students, perhaps in middle school may be very rich in information. Reasons for the importance of deterring math anxiety at a young age is that it is in middle school when students develop many of their long-felt feelings on things.

Concluding Remarks

The motivation behind this research comes from the wide-spread "math-hate" which is demonstrated by both students, and the public. As a mathematics educator, studying the possible reasons for this hate is extremely worthwhile. Mathematics is a discipline that can be very fulfilling for those who study it, and having accomplishments in it is very rewarding. Great educators believe that every student can learn, and that every student has the potential to have success at mathematics. For these reasons, no student should have to suffer from math anxiety. Becoming intimidated by mathematics may be normal, but it should not be paralyzing. Learning mathematics could be an enjoyable, rewarding experience for students, not full of anxiety, and there are notable actions teachers can perform to make this a reality.

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Appendix A

The participant consent form for the *Gulick Math Anxiety Scale*

To: Students of Math 110 or Math 122 or Math 210
From: Ms. Gulick
Date:
Re: Consent Form

- You are being asked to participate in a research project.
- To participate, you must simply come to class and complete two surveys.
- By signing the consent form, you are allowing Ms. Gulick to use the data you give on the surveys.
- These surveys will be given only once, and will be completed during class time. No more than 20 minutes will be required.
- The first survey involves a Likert scale, where you will be rating your feelings on a 1-5 scale. The second is a 10 words or less free response.
- Your name will not be used in any way. This study will not identify you personally. Only the data you offer will be used in this study.
- The risk involved is non-existent. Your grades in this class will not be jeopardized based on the data you offer.
- To make sure your identity is safe, your name will not be required on the surveys.
- Please remember this is a study is an attempt to better understand student views of mathematics, so Ms. Gulick may improve her teaching.
- There is <u>no penalty</u> for not signing the consent form.
- You may withdraw from this study without penalty.
- You will not be paid or given any reward for participation.

Student Consent Form

Thank you for being a part of this study. Please print and sign your name in the space provided to show that you agree to participate. Remember that signing the form allows Ms. Gulick to use your data for her research project.

Voluntary Consent: I have read this memo and I am fully aware of all that this study involves. My signature below shows that I freely agree to participate in this study. I understand that there will be no penalty for not participating. I understand that I may withdraw from the study at any time, also without penalty. I understand that my name and any other personal information will be kept out of the study. I understand that if I have any questions about the study, I may contact Ms. Gulick at 673-3866 or at gulick@fredonia.edu . Any further questions may be addressed by Ms. Gulick's supervisor, Dr. Keary Howard at keary.howard@fredonia.edu or by Maggie Bryan-Peterson at Maggie.Bryan-Peterson@fredonia.edu .

Please return this original, completed consent form as soon as possible. Thank you for your cooperation.

Student Name (Please Print): ____

Student Signature:____

Appendix B

The *Gulick Math Anxiety Scale*

Participant Information:

College Major:____

College status: Circle one

Freshman Sophomore Junior Senior

Ethnicity: Circle one

White (non-hispanic) African American Hispanic

Asian/Pacific Islander Native American Other

Sex: Circle one

Male Female

Gulick Math Anxiety Scale

Part 1: Rate each item in terms of how anxious you feel during the event specified.

	Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a bit of Anxiety	High Anxiety
1. Watching a teacher work an algebraic equation on a board					
2. Looking through pages in a math book					
3. Being asked to add up 976 and 777 in your head					
4. Thinking about taking a math test					
5. Determining the amount of change you should get back from a purchase involving several items					
6. Calculating a tip at a restaurant without using a calculator					
7. Having someone explain bank interest rates as you decide on a savings account					
8. Being asked by a friend to answer the question: How long will it take to get to New York City if I drive 70 miles per hour?					

Part 2: For each statement, express on the following five point scale, the extent of agreement between the feelings expressed in each statement, and your own personal feeling. The five points are: Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1. Mathematics makes me feel nervous					
2. I worry about my ability to solve mathematics problems					
3. I find mathematics interesting and useful					
4. I get uptight during math tests					
5. My mind goes blank, and I am unable to think clearly when working with math					
6. I would like to take more math classes					
7. The feeling I have towards mathematics is a good feeling					

Part 3: Rate yourself in terms of the level of math anxiety you feel you suffer from using the choices below by drawing an "x" in the corresponding box. Then, on the lines below give a brief reason (10 words or less) for why you believe you have this level of math anxiety.

No math anxiety	Low math anxiety	Moderate math anxiety	High math anxiety	Severe math anxiety

____

____

____

Appendix C

Format for organizing data in Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Student	Major	Status	Ethnicity	Sex	Anxiety Ratin	Question	Rating	Education?	1:0 or 122,210	M or NM	rating2	revisedrating	dimension
2	1	ENGL	FR	W	F	4	1	3		110	NM	3	3	math course
3	1	ENGL	FR				2	2		110	NM	4	2	math course
4	1	ENGL	FR				3	2		110	NM	4	2	everyday
5	1	ENGL	FR				4	5		110	NM	1	5	test
6	1	ENGL	FR				5	1		110	NM	5	1	everyday
7	1	ENGL	FR				6	1		110	NM	5	1	everyday
8	1	ENGL	FR				7	4		110	NM	2	4	everyday
9	1	ENGL	FR				8	3		110	NM	3	3	everyday
10	1	ENGL	FR				9	5		110	NM	1	5	attitude
11	1	ENGL	FR				10	5		110	NM	1	5	attitude
12	1	ENGL	FR				11	4		110	NM	2	2	attitude
13	1	ENGL	FR				12	5		110	NM	1	5	attitude
14	1	ENGL	FR				13	5		110	NM	1	5	attitude
15	1	ENGL	FR				14	1		110	NM	5	5	attitude
16	1	ENGL	FR				15	2		110	NM	4	4	attitude
17	2	MUSIC	JR	W	M	2	1	1		110	NM	5	1	math course
18	2	MUSIC	JR				2	1		110	NM	5	1	math course
19	2	MUSIC	JR				3	1		110	NM	5	1	everyday
20	2	MUSIC	JR				4	2		110	NM	4	2	test
21	2	MUSIC	JR				5	1		110	NM	5	1	everyday
22	2	MUSIC	JR				6	1		110	NM	5	1	everyday
23	2	MUSIC	JR				7	2		110	NM	4	2	everyday
24	2	MUSIC	JR				8	2		110	NM	4	2	everyday
25	2	MUSIC	JR				9	2		110	NM	4	2	attitude
26	2	MUSIC	JR				10	2		110	NM	4	2	attitude
27	2	MUSIC	JR				11	3		110	NM	3	3	attitude
28	2	MUSIC	JR				12	3		110	NM	3	3	attitude
29	2	MUSIC	JR				13	2		110	NM	4	2	attitude
30	2	MUSIC	JR				14	3		110	NM	3	3	attitude
31	2	MUSIC	JR				15	3		110	NM	3	3	attitude
32	3	ARTS	JR	W	F	3	1	2		110	NM	4	2	math course
33	3	ARTS	JR				2	2		110	NM	4	2	math course
34	3	ARTS	JR				3	3		110	NM	3	3	everyday
35	3	ARTS	JR				4	4		110	NM	2	4	test
36	3	ARTS	JR				5	4		110	NM	2	4	everyday
37	3	ARTS	JR				6	4		110	NM	2	4	everyday
38	3	ARTS	JR				7	3		110	NM	3	3	everyday
39	3	ARTS	JR				8	1		110	NM	5	1	everyday
40	3	ARTS	JR				9	3		110	NM	3	3	attitude
41	3	ARTS	JR				10	2		110	NM	4	2	attitude
42	3	ARTS	JR				11	3		110	NM	3	3	attitude

Appendix D

Results from *Gulick Math Anxiety Scale*