Math Anxiety in Fundamentals of Algebra Students

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Bio:

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Abstract:

This paper describes the current state of research and understanding of math anxiety, expounds upon this information with independent research conducted at UNT, evaluates this research, and suggests a plan for improved results in mathematics education. The independent research utilizes a simple survey to assess the level of anxiety of MATH 1010 students at the University of North Texas. MATH 1010 was chosen because it is a not-for-credit course that students who do not meet proficiency requirements for university-level math classes must take. Based on the 283 surveys utilized in the study as well as other research, it is clear that math anxiety is a real phenomenon with real consequences. More long-term studies will be required before the most effective abatement strategies can be identified and implemented.

Introduction

When people ask me what my major is, I tell them mathematics. There are two standard responses: “I hate math” and “Wow, that’s really hard.” These statements point out an obvious problem: many people fear and loathe math, a condition known as math anxiety. *Math anxiety* is an often-debilitating fear associated with manipulation of numbers and solving math problems (Tobias, 1987).

Math anxiety is a very interesting phenomenon, and not altogether foreign to me. In fact, I began suffering from math anxiety during my third year in college as a math major. Math was no longer effortless and I began to identify with the math-challenged students whom I was tutoring. Before then, the possibility of math anxiety had never crossed my mind.

I worked on campus for three years as a supplemental instructor tutoring math in traditionally high drop/fail/withdraw classes, all of which were in the first four math classes at the University of North Texas (UNT). Beginning with college algebra (MATH 1100), I saw that students dreaded coming to class, dreaded doing their homework, and got sweaty and fidgety during tests. I observed that they would leave class completely disheartened. A similar situation occurred in college math (MATH 1400), and also in college math with calculus (MATH 1680). The fear, lack of confidence, and downright dislike for math in these classes was astonishing, but it did not even begin to compare to the negative emotions in the fundamentals of algebra (MATH 1010). MATH 1010 is a not-for-credit class that is a prerequisite for students with insufficient math knowledge to successfully complete the two math classes required for graduation. Many of the students in MATH 1010 faced a much greater fear than others, so to better understand my students and their needs, I sought more information.

I have always enjoyed helping people with their math homework, but after realizing the challenges students with math anxiety face on a daily basis, I knew that it would take much more work and understanding to help these students succeed. At that point, I decided that I wanted to pursue a career in college-level mathematics, with the goals of understanding the learning process and developing a more effective method of mathematics instruction. The purpose of my research project was to develop an understanding of math anxiety that could be used to revamp mathematics education in the United States.

Throughout the United States, students are lacking an adequate understanding of mathematics. We are subpar to the rest of the world in this sense (Arem, 1993). The United States cannot retain its status as a world power if we cannot pull ourselves out of this downward spiral of math deficiency. Even if the international impact is ignored, a fundamental knowledge of mathematics is necessary for the basics of life, such as balancing a checkbook, calculating a tip for a waiter, and making sound financial decisions. More importantly, the process of learning math teaches students a system of linear thinking and problem-solving necessary for successful life skills that are not directly related to mathematics. We, as a society, can no longer accept failure in math as the norm if we are to continue to grow and develop socially, intellectually, and economically.

This paper will describe the current state of research and understanding of math anxiety, expound upon this information with independent research conducted at UNT, evaluate this research, and finally, discuss a plan for improved results in mathematics education.

Literature Review

Compared to other academic fields, research in math anxiety is fairly limited. Even so, there are several main ideas that resonate. Throughout my research, the existence of math anxiety

is not disputed. Arem (1993), Green (1990), Tobias (1987) and Hilton (1980) all agree that mathematics anxiety is prevalent and inhibits acquisition of math skills and knowledge. These authors have specific means of identifying this inhibitor. Arem goes through a list of common characteristics shared by math anxiety sufferers, as well as free-response questioning. Green uses a series of true-false written tests. Tobias leaves diagnosis up to the reader, and Hilton seems to assume that all students will at some point or another experience math anxiety.

Hilton directly blames “bad teaching, bad texts, and bad educational instruments” (Hilton, 1980, p. 176) for math anxiety. Ma’s (1999) studies indicated that some teachers lack the knowledge and background to effectively teach the subject. Less simply, Arem (1993) spends an entire chapter identifying specific causes for math anxiety for each individual by backtracking through their thought processes. Tobias (1987) describes several causes for math anxiety, including classroom style, emotions, and the preconception that the student is incapable. Zull (2002) elaborates on the emotional and chemical changes that occur in the brain during learning and testing. Green (1990) examines the literature for evidence of the existence of math anxiety and its courses. Math anxiety is a learned behavior, not a disorder, according to Selvin (1992): “Kids enter first grade with math as one of their favorite subjects, but by the end of elementary school, math is on the hit list” (p. 1200).

There is much treatment for math anxiety. In *Conquering Math Anxiety* (Arem, 1993) and *Succeed with Math* (Tobias, 1987), the authors focus on treatment techniques. Both cover extensive options concentrating primarily on positive thinking and effective test-taking strategies. Green (1990), however, takes a surprising direction to alleviate math anxiety. This study attempts to show that teachers’ comments on tests and homework are successful in reducing math anxiety. He finds that teacher comments are effective in calming math anxiety when used

in a systematic fashion. He also discovers that, although math anxiety reduces achievement, test anxiety has a greater effect on achievement than either math anxiety or teacher comments. In a broader approach, Zull (2002) delves deeply into the process, biology, and chemistry of learning. His intention is to explain the basics of understanding and to give teachers the necessary background knowledge to create more effective teaching strategies that may help overcome math anxiety.

A more recent and somewhat controversial method is HeartMath (Kurtzman, 2006). It is, according to the Institute of HeartMath, “[a] set of practical techniques and technologies to help people transmute stress and negative emotions in the moment, to improve performance and enrich the quality of life” (p. 12). The institute is a state and federally funded, nonprofit organization based in California. The institute uses biofeedback techniques to reduce stress and emotion, and, thus, improve critical thinking skills. It is not clear whether this method works because of a Hawthorne effect, or if it is truly successful in decreasing a student’s anxiety level.

Alternative teaching strategies include hands-on exercises and using concrete examples to illustrate abstract concepts. In order for these techniques to be successful, the teacher must be comfortable with math, and not fighting her own math anxiety (Selvin, 1992).

Zbornik (2001) points out that many math-anxious students display similar characteristics. They do not use trial and error or look for alternative solutions; additionally, they frequently skip problems that appear difficult, do not ask questions, and are reticent about seeking help. He suggests that these students may lack mental flexibility that would allow them to think of more than one way to solve a problem. Zbornik says that math anxiety is experienced on two levels: test anxiety and fear of number manipulation. Unfortunately, it is difficult to clearly identify a difference between the two fears. Many students experience math failure at such a young age that

math anxiety is sure to follow. Zbornik suggests certain teaching methods are necessary to remediate the problem. One possible approach is self-paced instruction with an end goal of confidence and competence in mathematics, therefore reducing math anxiety that is directly related to competence. Another approach is a highly structured instructional approach. For example, the teacher summarizes the previous lesson, clearly outlines instructional goals for the current lesson, presents the lesson with illustrative examples, and then reviews the current lesson with special attention to the main points. The final component is a student assignment that is carefully explained. This approach puts the responsibility on the teacher. Reading the book does not seem to be expected at this point; however, as one gains mathematical confidence, this too should be included in the learning process. Both of these methods place a high value on content mastery before proceeding to the next level (Zbornik, 2001).

Although research continues, it is clear that math anxiety is a problem. Unfortunately, there is little definitive data on which particular method of anxiety abatement is most effective. Furthermore, there are few long-term studies on the success of strategies to alleviate math anxiety.

Many scholarly articles analyze the problem, but present only anecdotal suggestions of treatment procedures with documented success. Scholars do agree that commitment on the part of both the student and the teacher will increase likelihood of success.

Explanation of Research

In an effort to better understand the challenges faced by math students, I employed a simple survey to assess the level of anxiety of UNT MATH 1010 students. MATH 1010 was chosen because it is a not-for-credit course. This course affects grade point average but cannot be used to fulfill university math credits. A student can opt into MATH 1010 without a placement

test; however, if one wants to take MATH 1100, one must pass a placement test. It would seem that students taking MATH 1010 would dislike math more than other math students because they are not getting credit, but they must pass this course to be eligible for a for-credit course. I intentionally selected a group for the study that would have a problem with math. Thus, results should not be interpreted to be representative of all college math students. To identify potential students, I obtained a list of MATH 1010 teachers from the course catalogue and then emailed the professors to ask for permission to visit their classes. Upon obtaining permission, I visited the classes, explained the survey, and asked students to participate. If they chose to participate, I passed out the paper survey. In all, 283 usable surveys provided data for the study.

When 283 MATH 1010 students were asked if they enjoyed math, 31% replied yes. Forty percent considered themselves proficient in math. More than half, 55.5%, reported that math made them anxious. Students were asked to rate their anxiety about math on a scale from 1 (indicating little anxiety) to 5 (indicating much anxiety). The average level of anxiety reported was 2.07. Of those that reported that math makes them anxious, their average score was 3.76. The frequencies for the level of anxiety are as follows: of the students reporting that math makes them anxious, 22.2% rated their anxiety level at 5 (the highest level), 39.4% rated it at level 4, and 22.6% rated it at level 3.

Forty-one percent reported that they were familiar with math anxiety. Students were asked: "Math anxiety is characterized by panic, paranoia, passivity, and a lack of confidence related to mathematics. Are these symptoms similar to your situation?" More than half (55.8%) reported yes.

It is startling that over 61% of students who report anxiety assess themselves as severely anxious. Breaking the data down further, as shown in Table 1, additional issues become known.

Those who like math are more likely to report that they are proficient in math than those students who do not like math – 64% among those who like math compared to only 23.2% among those who do not. The anxiety level is far higher in those who do not enjoy math. It is notable that among students who report enjoying math, 33.7% report suffering from math anxiety, compared to 65% among students who report they do not enjoy math. Data suggest that those who do not enjoy math are much more likely to report that they are familiar with math anxiety (46.4% compared to 29.2%), perhaps because these students are more likely to have math anxiety. Students who do not enjoy math report an average level of anxiety of 2.59, compared to 0.96 among those students who do like math. Students struggling in a subject, and their parents, will grasp any justification as to why they are struggling. Furthermore, there is a peculiar attraction to a justification that absolves the student and the parent from responsibility. Like Attention Deficit Disorder, math anxiety is a behaviorally diagnosed phenomenon, and one whose symptoms are easily manifested.

The word *proficient* was chosen specifically for its broad meaning. Proficiency can mean different things to different people. The question is designed ambiguously to assess the students' confidence level with the material. Whether they understand math was not assessed, but rather whether they *think* they understand it. Students who consider themselves proficient in math were compared with those who do not consider themselves proficient (see Table 2). Those who consider themselves proficient report higher levels of enjoyment of math (55.9%) than those who report that they are not proficient in math (17.6%). This is not unexpected, but it is not as large a difference as was expected.

Students who do not consider themselves proficient in math are also more likely than those who do consider themselves proficient to feel anxious about math (69.1% compared to

31.4%), to be familiar with math anxiety (43.5% compared to 36.6%), and to report suffering from math anxiety (68.0% compared to 34.4%). The average anxiety scores are also higher for those who believe they are not proficient compared to those who believe they are proficient (2.674 vs. 1.018).

In Table 3, students who report that math makes them anxious are compared with students who do not report that math makes them anxious. Students who report that math does not make them anxious are more likely to enjoy math than other students (50% compared to 16.6%), and they are more likely to report that they are proficient in math (55.6% compared to 20.4%). Those students who report that math makes them anxious are more likely to be familiar with math anxiety than are students who report math does not make them anxious (50.9% compared to 28.6%). They are also more likely to report that they suffer from math anxiety (89.2% compared to 14.3%).

As shown in Table 4, students who were previously familiar with the term *math anxiety* were more likely to report enjoying math and to consider themselves proficient in math than those who were not familiar with the term. However, students who were not previously familiar with the term were much more likely to report math anxiety than those who were familiar with it (73.0% compared to 43.7%), and to report higher levels of anxiety in response to math (2.58 compared to 1.73).

While I have confidence in my conclusions, I realize that this is preliminary data and that there are limitations to this study. Confounding factors were not evaluated and conclusions are suppositions based on limited data. The study population was narrowly defined, as the entire math population was not examined. For future research, background data would be useful. Examining previous education, family income, gender, race, years between math class

enrollment, standardized test scores throughout their education, and historical math difficulties would be useful and possibly provide additional insight into both cause and solution. Also, this study was directed only at certain MATH 1010 classes rather than all of them.

After the study was complete, I realized that the survey was not as functional and telling as I had intended. Even though I ran trials, the survey could be improved dramatically. On a positive note, the survey was very short, and therefore more people were willing to participate and the time required from class was minimal. However, the brevity may also limit the scope of the study.

Observations, Recommendations, and Possible Solutions

The need for a change of perception about math is necessary for American advancement; however, most students do not share this desire. They see math as a difficult, unnecessary, and uninteresting hurdle. There is a combination of solutions that should be implemented. They involve a change in attitudes toward math as well as improved math skill levels. Once attitudes are changed, the context for math education evolves accordingly.

Improved math proficiency is the other key to reducing math anxiety. Students must take responsibility for their own success. The support structure must strengthen itself: schools must hire proficient math teachers, supply them with the tools they need, and encourage results. Teachers must be proficient in the subject matter, as well as highly skilled in the art of teaching. There are numerous anecdotal success stories of gifted educators producing miraculous results. They have proven that commitment and dedication will result in well-educated students. The challenge is to translate their successes into methods and systems that can be taught to other teachers. The following suggestions have yet to be tested; however, further research will be

conducted and results will be published. Students, teachers, administrators, and society are the four main categories for which suggestions are presented in the next section.

Students

The learning cycle has been defined by many different scholars in many different ways; however, I will use the four-step process described by James Zull (2002) in *The Art of Changing the Brain*. Zull takes a biological approach to learning, stressing that learning follows a specific pathway determined by the makeup and natural shape of the brain. The learning process involves experience, reflection, abstraction, and action. These four steps do not necessarily follow this order, but all four steps are required to complete the learning cycle. Zull emphasizes various factors that contribute to learning.

I have gone through the learning process and created a student-based process for effectively learning a subject. On day one, the teacher is planning to cover Chapter One. To properly prepare for this lesson, the student will read Chapter One the day before and write down any major questions. This is a straightforward process. Reading the chapter gives the student experience. Organizing his or her thoughts into questions involves reflection and action. Asking oneself, “What didn’t I understand?” is the essence of reflection, and actually writing questions involves action. Preparation for class is completed. The student should go to class attentive and ready to learn. He or she should listen carefully, taking notes and making sure to write down everything the professor writes on the board. On a separate piece of paper, the student should write down aspects or topics that are unclear in the lecture. Many professors simply have too much to cover to spend a lot of time on reflection and abstraction during class; therefore, students mostly gain experience. Taking notes and being attentive serves the purpose of enhancing the experience portion of the learning cycle. Writing questions, however, involves the

other three steps. This may be challenging at first. The questions may seem trivial or there may not seem to be enough time to come up with questions. During class, questions with complete thoughts are not the goal. The purpose of writing questions is only to keep them from getting lost in a lecture. Attempting to answer questions at this time is strongly discouraged. During a full lecture there is rarely enough time to organize thoughts completely into an answer. The true bulk of learning does not occur in lecture. After the lecture, there are several steps the student should go through to maximize learning and minimize anxiety. These include:

- He or she should reread his or her notes.
- After rereading, translate class notes into the preferred form, whether that is outlining, bulleting, coloring, mapping, or any other note-taking method.
- Phrases should be in the student's words.
- After creating the new set of notes, the student should write side notes or processes and thoughts in the margin. This can include images, ideas, pictures, acronyms, or anything that will trigger the topic.
- Color-coding should be used if applicable.
- After reworking the notes, it is time to try to answer the questions from the first reading and from class.

This can take a lot of time and thinking. It requires all four parts of the learning process. If there are any questions left unanswered, note them. The student has used all four steps of the learning process. Rereading notes is reflection. Rewriting notes in one's own words involves abstraction. Color-coding is an action. However, we are not finished.

Some students complete this series of learning without too much effort. Where students and teachers fail is in making connections. Students go through this process, or something

similar, and have a grasp on the subject. They know what to do and they know how to do it.

What they do not know, however, is why or how it relates to anything else. In Liping Ma's (1999) *Knowing and Teaching Elementary Mathematics*, she consistently found that while American teachers may memorize an algorithm or a method, they rarely understand the connection to other aspects, the reasoning behind the algorithm, or other methods of solving the same problem.

When the teacher lacks this knowledge, we cannot expect the student to grasp. However, we do.

Although the teacher may not be teaching these connections, students are capable of creating and understanding their own. To complete the learning process and really grasp and understand a concept, the student should create a flow chart of sorts: webs, a tree, connected dots, a list, a depiction of connections between concepts. Things included should be knowledge required to understand the topic, how it relates to a similar topic, other methods of solving the same problem, connections to other fields, and applications to other topics. This is the most difficult aspect, the most important, and the most forgotten aspect of learning.

Frequently, students are not taught to look for these connections. This is partially the fault of the teacher. Students do not see teachers making connections and, therefore, do not perceive this aspect as important. Teachers, however, have every opportunity to change this shortcoming.

A teacher casually pointing out connections will subconsciously encourage students to do the same. According to Zull (2002), we mimic what works, and if the student wants to succeed, he or she mimics the teacher. If the teacher is pointing out connections, the students will as well. The teacher also has every possibility to create new connections with a smell, a sound, a picture, a story, a motion, or anything that will physically stimulate the student to create a connection.

However, what happens when students are not interested in learning?

The age-old question of how to teach students who do not want to learn cannot be answered with one simple sentence. That being said, a student learns when he or she participates in the learning process. There are endless possibilities of projects and methods that will encourage the student to engage in all four parts of learning. Most teachers lecture and give homework. The student goes through experience and half the action, thereby missing reflection, abstraction, and the action that results from both. Projects specific to the topic can be assigned to encourage reflection, abstraction, and inherently cause action. There are many arguments against projects, some of which include subjective grading, time, and the energy required to do the projects, but these will be addressed later. If the teacher desires to omit projects, talking and debating are effective as well. Downfalls of debating include a strong advantage to those who prefer to speak instead of write, a lack of time for complete thoughts, and the pressure of being on the spot. Both methods are effective. I do not have a definite answer because I do not believe one exists. Because students learn in different ways and all teachers differ in their teaching styles, flexibility is required. There are methods that work, and teachers have the opportunity to discover new methods everyday.

The best efforts of educators cannot be successful without commitment from students. Students should be challenged to take personal responsibility for academic success. The notion of math anxiety as an excuse is unacceptable. At the same time, math anxiety is a legitimate barrier to math educational success. Just as educators strive to employ teaching methods aimed at overcoming math anxiety, students must strive to gain the mathematical skills that will counteract the effects of math anxiety. An open mind is required of teachers and students, as well as a positive outlook, and a commitment to success.

Teachers

In addition to points about teaching made earlier, teachers should use all their creativity to make math education as successful and enjoyable as possible. Just as teachers strive to instill a lifelong love of reading, they should likewise inspire, if not a love of math, at least a comfortable relationship with numbers. Math anxiety is a learned behavior. Care should be taken that teaching results in math proficiency, not math anxiety. Math anxiety is contagious, which makes it crucial that teachers overcome their own issues with it. In a perfect world, the supply of well-trained teachers would meet the demand. Unfortunately, this is not the case. School administrators and educational leaders have an important role to play in raising math education expectations and providing the educational resources necessary to meet expectations.

As described in previous sections, many different options are available ranging from very hands-off to very hands-on approaches; however, each student learns differently. The most important knowledge a teacher could instill in his or her students is to encourage them to take pride in their work and education.

Administration

Just as students should be set up to succeed, teachers must be as well. Teachers should have freedom to innovate if it produces the desired result. Tools for creative and hands-on learning are just as important as textbooks, pencils, and paper. School administrators, as well as the government educational hierarchy, should aim for true functional success in math, not just standardized test success.

Society

Students, parents, educators, employers, and society must stop accepting mediocre results, which means that the attitude that it is acceptable to be “terrible at math” must end. If college

professors in the humanities laugh off the inability to “do the math,” how can we expect their students to embrace the beauty, challenge, and necessity of math?

A more effective tool for measuring mathematical understanding is required. Most standardized math placement and evaluation tests at the lower levels are primarily multiple choice and cannot accurately measure math understanding.

Racial and gender stereotypes as they relate to math proficiency need to be overcome. Girls and minorities should not be embarrassed to be math whizzes. This writer on more than one occasion has been told, “You’re too pretty to be a math major.” This is absurd. Mathematics is not confined to unattractive white males, contrary to popular belief. There is no biological basis excluding women and minorities from mathematics, only societal biases.

Solutions to the problem of math anxiety lie in the collaborative efforts of students, teachers, and administrators at all levels. Additionally, our society must put a high value on math literacy. People laugh off being dumb at math, and there is no social stigma associated with being mathematically illiterate. Concerted effort on all fronts can mitigate, reduce, or even eliminate math anxiety.

Conclusion

It is clear that math anxiety is a real phenomenon. It is rooted in social programming and inadequate foundation for progression in mathematics. Solutions lie in recognizing the problem, changing attitudes toward math, and improving math education beginning in elementary school and continuing through the college level.

For my part, I will begin my career as a Teach For America corps member, teaching high school math to an at-risk student population. I expect these students to teach me a great deal about the challenges of successfully teaching math. Throughout this process, I will continue my

research and identify ways for students, teachers, and the support structure to overcome math anxiety and raise the level of math literacy in the United States.

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Table 1. Percentage of students who enjoy math and those who do not enjoy math who report being proficient in math and having math anxiety

Math anxiety	Percent who enjoy math who:	Percent who do not enjoy math who:
Consider self proficient in math	64.0%	23.2%
Report feeling anxious about math	29.2%	67.9%
Are familiar with math anxiety	29.2%	46.4%
Report suffering from math anxiety	33.7%	65.0%
Average anxiety level	0.96	2.59

Table 2. Percentage of students who report they are proficient in math and those who are not proficient in math who report enjoying math and having math anxiety

	Percent who do not consider themselves proficient in math who:	Percent who consider themselves proficient in math who:
Report enjoying math	17.6%	55.9%
Report feeling anxious about math	69.1%	31.4%
Are familiar with math anxiety	43.6%	36.6%
Report suffering from math anxiety	68.0%	34.4%
Average anxiety level	2.674	1.0198

Table 3. Percentage of students who report math makes them anxious and those who report math does not make them nervous who report enjoying math, being proficient in math, and having math anxiety

Math anxiety	Percent who report that math makes them anxious who:	Percent who do not report that math makes them anxious who:
Report enjoying math	16.6%	50.0%
Consider self proficient in math	20.4%	55.6%
Are familiar with math anxiety	50.9%	28.6%
Report suffering from math anxiety	89.2%	14.3%
Average anxiety level	3.881	NA

Table 4. Percentage of students who report being familiar with math anxiety and those students who do not report being familiar with math anxiety who report enjoying math, being proficient in math, and having math anxiety

Math anxiety	Percent who report being familiar with math anxiety who:	Percent who report not being familiar with math anxiety who:
Report enjoying math	37.7%	22.6%
Consider self proficient in math	38.9%	32.2%
Are familiar with math anxiety	45.8%	68.7%
Report suffering from math anxiety	43.7%	73.0%
Average anxiety level	1.73	2.58