Math Anxiety in Fundamentals of Algebra Students

Sara Draznin
UNT College of Arts and Sciences
Mathematics
Spring 2008

Sara Andrea Draznin

Dr. Neal Brand, Mathematics

Dr. Gloria Cox, Honors College Dean
I. Introduction

When people ask me what my major is, I tell them mathematics. There are two standard responses: “I hate math.” or, “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).

Math anxiety is a very interesting phenomenon, and not all together 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 that 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 to traditionally high drop/fail/withdraw classes, all of which were in the first four math classes at UNT. Beginning with College Algebra (MATH 1100), I saw how students dreaded coming to class, dreaded doing their homework, and got sweaty and fidgety during tests. I observed how 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 didn’t even begin to compare to the negative emotions in 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 are facing on a daily basis, I knew that it would take much more work and understanding to help these students succeed. At this point, I decided that I want to pursue a career in college level mathematics with the aim of understanding the learning process more effectively and developing a more effective method of mathematics instruction. My goal is for this research project to be a springboard for additional studies that will lead to a program to revamp the mathematics education program in the United States in three main sectors: math students, math teachers, and the support structure.

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). 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 like balancing a checkbook, calculating a tip for a waiter, and making sound basic financial decisions. But 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 mathematical failure 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 the University of North Texas, evaluate this research, and finally, discuss a plan for improved results in mathematics education.
II. State of Research

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.

Lead authors have a specific means of identifying this inhibitor. Arem (1993), a psychologist goes through a list of common characteristics shared by math anxiety sufferers as well as free response questioning. Green (1990) uses a series of true-false written tests. Tobias (1987) leaves diagnosis up to the reader, and Hilton (1980) 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, 176) for math anxiety. Ma’s (1999) studies indicated that teachers very possibly lack the knowledge and background to effectively teach the subject. Less simply, Arem (1993), using her psychology background, spends an entire chapter identifying specific causes for math anxiety for each individual by going through a backtracking thought process exercise. Tobias (1987) describes several causes for math anxiety, some of which include a preconceived notion that the student is incapable, classroom style, and emotions. Zull (2002) elaborates on the emotional and chemical changes that occur in the brain during learning and testing. In his study, Green does not personally study causes of math anxiety, but instead relies on a very detailed literature review for proof of the existence of math anxiety and a series of causes for math anxiety. Math anxiety is a learned behavior, not a disorder (Selvin). “Kids enter first grades with math as one of their favorite subjects, but by the end of elementary school, math is on the hit list” (Selvin, 1200).
Treatment for mathematics anxiety is the most diverse area in math anxiety research. In *Conquering Math Anxiety* (Arem, 1993) and *Succeed with Math* (Tobias, 1987), the goal of the book is treatment. Both cover extensive options focusing mostly on positive thinking and effective test-taking strategies. Green (1980), however, takes a slightly surprising direction to alleviate math anxiety. Instead of a methodology pre-test, this study attempts to show an improvement in reducing math anxiety with teacher’s comments on tests and homework. He finds that teacher comments are very effective for calming math anxiety when used in a systematic fashion. He also discovers that test anxiety has a greater effect on achievement than math anxiety or teacher comments. In a broader approach, Zull (2002) delves deeply into the process, biology, and chemistry of learning with the intention of explaining the basics of understanding and giving teachers the necessary background knowledge to create more effective teaching strategies that may help overcome anxiety.

A somewhat controversial method is HeartMath (Kurtzman). 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,” (Kurtzman, p 12). The institute is a state and federally-funded non-profit organization based in California. Its uses biofeedback techniques along with literally being connected to a computer that uses a color coding system to reduce stress and emotion and thus improve critical thinking skills. It is not clear whether this method works because of a placebo effect or if it is truly successful in increasing a student’s coherence. In any case, this method focuses primarily on anxiety issues more than basic skill building.

Alternative teaching strategies include hands-on exercises, using concrete examples to illustrate abstract concepts, allowing the students to “experience the thrill of discovery.” In order
for this technique to be successful, the teacher must be comfortable with the math and not fighting his or her own math anxiety (Selvin).

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, don’t 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 (2001) says that math anxiety is experienced on two levels: test anxiety and fear of number manipulation. Unfortunately, it’s difficult to clearly identify a difference between the two fears. Many students experience mathematical failure at such a young age that mathematics anxiety is sure to follow. Zbornik (2001) 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 illustrations, the teacher summarizes the previous lesson, clearly outlines instructional goals for the current lesson, presents lesson with illustrative examples, 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 which particular method of anxiety abatement is most effective.
Further, there are few, if any, long-term studies on the success of strategies to alleviate math anxiety.

There is a troubling consistency in the scholarly articles where only problem analysis exists, but at best presents anecdotal suggestions lacking documented scientific success.

Scholars do agree that commitment on the part of both the student and the teacher will increase likelihood of success.
III. 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. MATH 1010 affects GPA 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, as they are not getting credit, but must pass this course to be eligible for a for-credit course. I intentionally selected a group for the study that would like have 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 which is attached in the appendix. Two hundred eighty-three usable surveys provided data for the study.

When 283 MATH 1010 students were asked . . . .

Do you enjoy math? 31% replied yes.

Would you consider yourself proficient in math? 40% replied yes.

Does math make you anxious? 55.5% replied yes.

If so, how anxious?

<table>
<thead>
<tr>
<th>Little anxiety</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Much anxiety</th>
</tr>
</thead>
</table>

The overall anxiety level was 2.07.

Of those that reported that math makes them anxious, 3.76 was the average score.
Math Anxiety: 9

| Reported a 5 | 22.2% |
| Reported a 4 | 39.4% |
| Reported a 3 | 22.6% |
| Reported a 2 | 12.3% |
| Reported a 1 | 0.6% |

Are you familiar with math anxiety? 41% reported yes

Math anxiety is characterized by panic, paranoia, passivity, and a lack of confidence related to mathematics. Are these symptoms similar to your situation?

55.8% reported yes

It is startling that over 61% of students that report anxiety assess themselves as severely anxious. Breaking down the data further, some more issues come to light.

<table>
<thead>
<tr>
<th>Of those that enjoy math:</th>
<th>Of those that don’t enjoy math:</th>
</tr>
</thead>
<tbody>
<tr>
<td>64.0% consider themselves proficient</td>
<td>23.2% consider themselves proficient</td>
</tr>
<tr>
<td>29.2% report feeling anxious about math</td>
<td>67.9% report feeling anxious about math</td>
</tr>
<tr>
<td>29.2% are familiar with math anxiety</td>
<td>46.4% are familiar with math anxiety</td>
</tr>
<tr>
<td>33.7% report suffering from math anxiety</td>
<td>65.0% report suffering from math anxiety</td>
</tr>
<tr>
<td>0.96 is the average anxiety level</td>
<td>2.59 is the average anxiety level</td>
</tr>
</tbody>
</table>

The anxiety level is far higher in those that do not enjoy math. It is notable that even though students report enjoying math, 33.7% still report suffering from math anxiety. Data suggests that those that do not enjoy math are much more familiar with math anxiety. This could be for a number of reasons, one of which is that someone suggested that the student has math anxiety. Students struggling in a subject, and their parents, will grasp on to 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.

**Of those that consider themselves not proficient in math:**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17.6% report enjoying math</td>
<td>69.1% report feeling anxious about math</td>
<td>43.6% were familiar with math anxiety</td>
</tr>
<tr>
<td>68.0% report having math anxiety</td>
<td>2.674 is the average math anxiety score</td>
<td></td>
</tr>
</tbody>
</table>

**Of those that consider themselves proficient in math:**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>55.9% report enjoying math</td>
<td>31.4% report feeling anxious about math</td>
<td>36.3% are familiar with math anxiety</td>
</tr>
<tr>
<td>34.3% report having math anxiety</td>
<td>1.0198 is the average math anxiety score</td>
<td></td>
</tr>
</tbody>
</table>

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. It is to be expected that those who consider themselves proficient would enjoy math more, but the level of enjoyment is not as high as I would have anticipated.

**Of those that report that math makes them anxious:**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16.6% enjoy math</td>
<td>20.4% consider themselves proficient</td>
<td>50.9% are familiar with math anxiety</td>
</tr>
<tr>
<td>89.2% report suffering from math anxiety</td>
<td>3.881 is the average anxiety level</td>
<td></td>
</tr>
</tbody>
</table>

**Of those that report that math does not make them anxious:**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>50.0% enjoy math</td>
<td>55.6% consider themselves proficient</td>
<td>28.6% are familiar with math anxiety</td>
</tr>
<tr>
<td>14.3% report suffering from math anxiety</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We reveal the power of suggestion by the fact that 14.3% of those that report that math does not make them anxious claim to suffer from math anxiety.
Of those familiar with math anxiety:

37.7% enjoy math
38.9% consider themselves proficient
45.8% report math makes them anxious
43.7% report suffer from math anxiety
The average anxiety level is 1.73

Of those not familiar with math anxiety:

22.6% enjoy math
32.2% consider themselves proficient
68.7% report math makes them anxious
73.0% report suffer from math anxiety
The average anxiety level is 2.58

Upon reading the definition of math anxiety, 73.0% of those that had not previously encountered math anxiety diagnose themselves as sufferers, however before reading the definition, only 68.7% report that math makes them anxious. This represents a five percent increase in math anxiety by suggestion. It is thus difficult to get a true and valid accounting of the prevalence of math anxiety. It is reasonable to infer that a similar distortion could occur with identification with math anxiety by an educational or psychological professional.

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. Also, because one of the classes surveyed was very large, at about 300 students, data may be heavy for large class room settings. 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.

Post study I realized that the survey was not as well put together as I had initially desired. 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.
IV. 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 to cross. 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 and parents 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. There is a section for four main categories: students, teachers, administration, and society.

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 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. Throughout *The Art of Changing the Brain*, 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 fairly 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. Writing questions is only to keep questions 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:
• He or she should reread his or her notes.
• After rereading, translate class notes into the preferred form, whether that is outlining, bulleted, 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 utilized if applicable.
• After reworking the notes, it is time to try to answer the questions from the first read 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 utilized 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. But we are not finished.

Some students complete this series of learning without too much effort. But where students and teachers alike 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 *Knowing and Teacher 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 these aspects, we cannot expect the student to grasp them. But we do. And while 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 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. As a teacher, casually pointing out connections will subconsciously encourage students to do the same. According to Zull, 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. But what happens when students are not interested in learning?

The age-old question of how to teach students that do not want to learn cannot be answered with one simple sentence. That being said, a student learns when he or she completes the learning process. As a teacher, there are endless possibilities of projects and methods that will encourage the student to do all four parts of learning. Most teachers lecture and give homework. The student has gone through experience and half the action. They are missing reflection, abstraction, and the action that results from those two parts. Projects specific to the topic can be assigned to encourage reflection and abstraction and inherently cause action. There are many arguments against projects, some of which including subjective grading, time, and the
energy required to do the projects, but these will be addressed at a later date. 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, however. I do not have a definite answer because I do not believe one exists. Because all students are different learners and all teachers are different teachers, 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. Just as an open mind is required of teachers, students as well need an open mind, a positive outlook, and a commitment to success.

Teachers

Teachers should use all their creativity to make math education as successful and enjoyable as possible. Just as teachers strive to instill a lifetime love of reading, they should likewise inspire, if not a love of math, a comfortable relationship with numbers. Math anxiety is a learned behavior. Care should be taken that math proficiency, not math anxiety, is the result of lessons. Math anxiety is contagious, which makes it crucial that teachers overcome their own issues with math anxiety. 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
Math Anxiety: 18

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 bit of knowledge a teacher could instill in his or her student is to encourage each of
them to take pride in him or her 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 not being able 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 has on more than one occasion 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 synthesis of 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.
V. Conclusion

It is clear that math anxiety is a real phenomenon. It is rooted in social programming and inadequate foundation for progression in mathematics study. 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.
References


Appendix

Thesis Questionnaire

1. Do you enjoy math? 1. Yes 2. No

2. Would you consider yourself proficient in math? 1. Yes 2. No


4. If so, how anxious?
   Little anxiety 1 2 3 4 5 Much anxiety

5. Are you familiar with math anxiety? 1. Yes 2. No

6. Math anxiety is characterized by panic, paranoia, passivity, and a lack of confidence related to mathematics. Are these symptoms similar to your situation?
   1. Yes 2. No

7. If not, how does math make you feel?