NSU Florida
NOVA SOUTHEASTERN UNIVERSITY

Transformations

Volume 1
Issue 1 *Winter 2016*

Article 3

1-1-2016

Mathematics Anxiety in Society: A Real Phenomena and a Real Solution

Joseph M. Furner
Florida Atlantic University, jfurner@fau.edu

Carol A. Marinas
Barry University, drmarinas@yahoo.com

Mathematics Anxiety in Society: A Real Phenomena and a Real Solution

By Joseph M. Furner

and

Carol A. Marinas

Dr. Joseph M. Furner (Florida Atlantic University) jfurner@fau.edu

Dr. Carol A. Marinas (Barry University) drmarinas@yahoo.com

Abstract

While math anxiety still remains a real issue affecting student performance and confidence, today it is even more critical with the greater emphasis on producing more students for careers in STEM fields. In an effort to understand ways to ease math anxiety and encourage adaptive achievement behaviors to deal with such anxiety, this paper will explore the topic and provide research-based practices in providing a solution to this existing problem in our schools. There are many studies that show using technology in the teaching of mathematics will help to alleviate math anxiety and encourage students to enjoy learning mathematics. GeoGebra, a dynamic mathematics software, can assist in developing a deeper understanding of geometric/measurement/algebraic concepts in the mathematics classrooms from Grades K-16. Emphasis on addressing math anxiety as a teacher and using technologies like GeoGebra software to teach math are the main foci of the paper.

Keywords: Math Anxiety, Best Practices, STEM, GeoGebra, Technology, Geometry, Common Core State Standards

Introduction

"Of all of our inventions for mass communication, pictures still speak the most universally understood language."
--- Walt Disney Company

Image 1: The Math Anxiety Issue Exists in Society

The above photograph was taken recently outside a pub in South Florida, USA. The sign reads, "4 out of 3 people have trouble with math." Obviously, the owner there was making fun of the problem in our society and the sentiment about how we feel about mathematics. Having been mathematics teachers now for almost 30 years each, the authors have heard on numerous occasions that when we tell someone we are math teachers, most people say it was their worst or most despised subject.

In today's world, it is critical to encourage young people's confidence in their mathematical ability and their willingness to set goals to pursue math-related academic and professional careers in STEM fields (Science, Technology, Engineering, and Mathematics). The National Council of Teachers of Mathematics (NCTM) in their 1989 Standards, created societal goals for our young people, one being a creation of mathematically confident learners. As Boaler (2008) points out, it is critical to ensure students are confident and well-prepared in mathematics if they are going to compete for high-tech jobs today and in the future. Mathematics anxiety is a real phenomenon in today's society in many countries around the world. Helping students identify

and address their math anxiety is critical in helping them cope with and overcome such anxiety that otherwise may negatively impact future choices in their academic and professional careers.

Strauss (2015) states that the 2015 scores for the National Assessment of Educational Progress (NAEP) are available and the news is not good for those who think standardized test scores tell us something significant about student mathematics achievement in the USA. She feels that it is difficult to see any real growth across the board since 2011 with math scores backsliding to 2009 levels. Heitin (2015) noted that sixteen states saw declines in 4th grade math scores. Other than Mississippi and Washington, D.C., only the Department of Defense schools had increases in average scores. Unfortunately not a single state had an increase in 8th grade math scores. Twenty-two states had declines in 8th grade math. Heitin feels that NAEP has long been seen as an independent indicator of achievement, and it was not designed to be aligned to a particular set of standards. One thing these educators and the NAEP seem to always neglect to mention is the level of math anxiety that may contribute to student success in mathematics in the USA. Math anxiety is a real phenomenon and needs to be addressed in our schools to increase student achievement and success. More needs to be done to improve math achievement scores and attitudes toward mathematics overall.

Math Anxiety

Math anxiety is defined as feeling of anxiety that one cannot perform efficiently in situations that involve the use of mathematics. Although it is mostly associated with academics, it can apply to other aspects of life (eHow Website, n.d.). Richardson and Suinn (1972) originally defined math anxiety as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Mathematics anxiety is the "irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations" (Buckley and Ribordy, 1982, p. 1).

Geist (2010) argues that negative attitudes toward mathematics and math anxiety are serious obstacles for young people in all levels of schooling, and an anti-anxiety curriculum is critical in building students' confidence when working with mathematics. Math anxiety is defined as a feeling of panic, helplessness, paralysis, and mental disorganization that arises when some students are confronted with a mathematical task (Núñez-Peña, Suárez-Pellicioni, & Bono, 2013). It is a well-documented phenomenon that has affected our society for over forty years with little being done to address it in our classrooms or the way we teach math. Beilock and Willingham (2014) state that, "Because math anxiety is widespread and tied to poor math skills, we must understand what we can to do alleviate it" (p. 29). Educators today need to address this very important issue if they want to see more students have success with mathematics and go into STEM related fields. In its assessment practices, the National Council of Teachers of Mathematics (NCTM) (1989 & 1995) recognized math anxiety as a problem and specifically included it. Standard #10 (NCTM, 1989) prompts teachers to assess their students' mathematical dispositions, such as confidence in using math to solve problems, communicating ideas, and reasoning.

In addition, many people often blame their failures on their lack of a mathematical mind, the notion that men are better than women at math, or that they have poor memories. Sheila Tobias, an expert on the topic of math anxiety since the 1980's, contends that there are two myths about mathematics that need to be eliminated. One is that higher level math is too difficult for otherwise intelligent students to master, and another is that without mathematics you can live a productive intellectual and professional life (Tobias, 1993). Females who believe their math skills are fixed and unchangeable (a fixed or entity view of intelligence that is correlated with performance goals) are less likely to identify with math and show less interest in math than those women who believe their math skills are malleable (growth view of intelligence associated with mastery goals), and those women are more likely to fall prey to the gender gap that currently exists in mathematics (Burkley, Parker, Stermer, & Burkley, 2010). We suggest that these affective factors, including students' attitudes, interest, and potential anxiety for learning math, will affect students' performance and therefore should be taken into account in attempts to improve students' learning processes.

Jackson and Leffingwell (1999) reported that only 7% of the college students in their study did not express math anxiousness. Similarly, Perry (2004) indicated that 85% of students in an introductory college level math class claimed to have experienced anxiety when presented math problems. Even in populations of students where math is a foundational skill (e.g. engineering majors in college), researchers have found math anxiety to be present (Hembree, 1990; Ruffins, 2007). As the STEM fields become more important for our students to study, our schools and teachers need to do more to address math anxiety so that our students are confident to study STEM-relate areas (Sparks, 2011).

Both teachers and parents play a critical role in helping to develop positive dispositions toward math. As with most intervention programs, early assessment and action help to develop positive math attitudes. Ooten (2003) outlines a four-step method for managing a person's math anxiety: helping students come to terms with their feelings, challenging their current beliefs, and realizing they are not alone; using intervention strategies to address negative thinking and realize they can be successful at math; reflecting on personal learning styles and modes; and applying learning to mathematical situations as confidence and strategies for doing mathematics increase. These techniques require the teacher's awareness of a student's math anxiety as well as their willingness to support the student in alleviating that anxiety.

Attention to teaching methods that are effective at overcoming math anxiety is important for teacher preparation as well as for in-service math teachers. A student's lack of success with math may be a cause of math anxiety and heightened by any one of several factors: poor math instruction, an insufficient number of math courses in high school, unintelligible textbooks, or misinformation about what math is and what it is not. Research by Oberlin (1982) and Furner (1996) found that some teaching techniques actually cause math anxiety; (a) assigning the same work for everyone, (b) covering the book problem by problem, (c) giving written work every day, (d) insisting on only one correct way to complete a problem, and (e) assigning math problems as punishment for misbehavior. Further, teachers and parents who are afraid of math

can pass on math anxiety to the next generation by modeling behaviors of their own discomfort with the subject.

How to reduce math anxiety:

1. Using "Best Practice" in mathematics such as:

   According to Zemelman, Daniels, and Hyde (2015), we need to use best practices in teaching math to make math instruction most effective, things such as:

   - Use of manipulatives (concrete math)
   - Cooperative group work
   - Discussion of math
   - Questioning and making conjectures
   - Justification of thinking
   - Writing in math: thinking, feelings, and problem solving
   - Problem-solving approach to instruction
   - Content integration and real-life application
   - Use of calculators, computers, and all technology
   - Being a facilitator of learning
   - Assessing learning as a part of instruction

2. Incorporating the NCTM and State/Common Core Math Standards into the curriculum and instruction.

3. Discussing feelings, attitudes, and appreciation of mathematics with students. Most research shows that until a person with math anxiety has confronted this anxiety by some form of discussion/counseling, no "best practices" in math will help to overcome this fear (Furner, 2007).

4. Psychological techniques like anxiety management, desensitization, counseling, support groups, bibliotherapy, and discussions.

As teachers, we need to include activities like a math attitude survey (Appendix A) or read the book *Math Curse* (Scieszka and Smith, 1995) to get students to talk about true feelings toward mathematics. Using surveys and getting our young people to talk about how they feel about mathematics are some of the first steps toward helping them to gain confidence toward math.

Professor Freedman Provides Math Help at: http://www.mathpower.com

- Math Teachers' Ten Commandments
- Math Anxiety Self-Test
- Ten Ways to Reduce Math Anxiety
- Students' Math Bill of Rights
- Study Skills Tips
- Math Anxiety Code of Responsibilities
- Other Links to Math Help

At the *Mathitudes Online* website (See Appendix B) one can find a multitude of web links related to math anxiety research. A famous quote from W. V. Williams (1988), "Tell me mathematics, and I will forget; show me mathematics and I may remember; involve me...and I will understand mathematics. If I understand mathematics, I will be less likely to have math

anxiety. And if I become a teacher of mathematics, I can thus begin a cycle that will produce less math-anxious students for generations to come." (p. 101) is a reminder of how critical it is to teach for understanding making things as hands-on and real-world as possible.

"If math teachers do something about helping their students to develop their confidence and ability to do math, we can impact their lives in a positive way forever" and "Our students' careers and ultimately many of their decisions they will make in life could rest upon how we decide to teach math. We must make the difference for the future of our kids in an ever growing, high-tech, competitive, global world which depends so heavily on mathematics." (Furner, 2009, p. 27) The authors strongly feel that math teachers need to start out each school year by giving their students a "Mathitudes Survey" of some sort, and there are many online (Appendix A). This will serve as a gauge for teacher to see who and how many are math anxious students in their class and to take the time working with these students to build the necessary confidence in mathematics to be successful in life and a world of STEM.

Technology Use in the Teaching of Mathematics to Address Math Anxiety

The use of technological tools is critical in today's world. Our students need to work at higher levels of generalization, model and solve complex problems, and focus on decision-making and reasoning (National Council of Teachers of Mathematics (NCTM) 1989, 2000, 2006). NCTM believes mathematical power can arise from technology that includes: increased opportunity for learning, increased opportunities for real-life social contexts, and orientation to the future.

NCTM (1989) defines technology in school mathematics as:

* digital tools
* computers
* calculators
* other handheld devices
* dynamic software
* podcasts
* interactive presentation devices
* spreadsheets
* Internet-based resources
* emerging technology and novel uses of technology

NCTM's focus in using technology is to: promote technology as an essential tool for learning mathematics in the 21st century, integrate the principles and process standards with teaching the content standards, and provide access to all five mathematics content standards for all students. By providing learner-centered strategies that address the diverse needs of all learners of mathematics, NCTM feels that effective teachers maximize the potential of technology to: develop students' understanding, stimulate their interest, and increase their proficiency in mathematics.

Alday and Panaligan (2013) found in their empirical study that using technology to teach math reduces math anxiety in students while enhancing more positive attitudes toward mathematics. This study found that teaching topics related to circles and parabolas taught using technology, since these topics can best be presented through diagrams that can be shown through animation and visual presentation on a computer would enhance the learning of students with such technology use. The results of this study for the particular math topics that there was a positive

effect on the use of technology use since there was an improved score for the experimental group on the topics considered thus reducing math anxiety.

Iossi (2013) provides a summary of analysis of research on math anxiety research and found that using technology when teaching mathematics can help to foster math understanding while lowering math anxiety. Iossi (2013) claims that technology use to cope with math anxiety is rarely reported in the literature. Iossi reiterated in her paper the research from Goldberg and Waxman (2003) who found as learners experienced successes with using technology their quantiphobia decreased and, students were more confident about enrolling in additional mathematics courses, their study used technologies like Excel to teach statistics and data analysis. There seems to be several reports now demonstrating how technology may be a tool for minimizing such anxiety toward mathematics.

As described by Mishra and Koehler (2006), Technological Pedagogical Content Knowledge (TPCK) is the basis of good teaching with technology and requires not only content knowledge or pedagogical knowledge, but an understanding of the conceptual representation to build on existing knowledge.

Math teachers need to ask themselves some tough questions when it comes to professional development and employing technology into their teaching of mathematics, questions like:

- What role does technology play in providing multiple representations and opportunities for communication to help students develop mathematical understanding?
- How does technology influence your instructional decisions? And, how do your instructional decisions influence your use of technology?
- How can technology increase access to significant mathematics to all students? How do you promote social justice for access to and facility with technology in learning mathematics?
- How are you thinking differently about your use of technology? What are some of the steps you plan to take to promote growth in your own use of technology?

In research by Fahlberg-Stojanovska, & Stojanovski (2009), they found that using GeoGebra motivates and helps students learn at a higher level while exploring conjectures as they draw and measure. Rosen & Hoffman (2009) found that it is very important to integrate both concrete and virtual manipulatives into the math classroom, such as representational models like GeoGebra. Furner & Marinas (2007) found that young people can easily transition from the concrete to the abstract when using manipulatives like geoboards and using geometry sketching software like GeoGebra. The Appendix B provides online websites on resources related to GeoGebra.

Today's mathematics teachers need to check for dispositions toward math and also use best practices like using technology like GeoGebra to help students gain confidence to explore mathematics in positive and exciting ways that appeal to young people today like employing technologies. As seen above from the current research, there is a great deal of research supporting using technology to help address math anxiety when teaching mathematics. The idea of looking closely at math anxiety levels, motivation to learn mathematics, and using technology like GeoGebra to teach and motivate students is critical today in a world of STEM.

GeoGebra

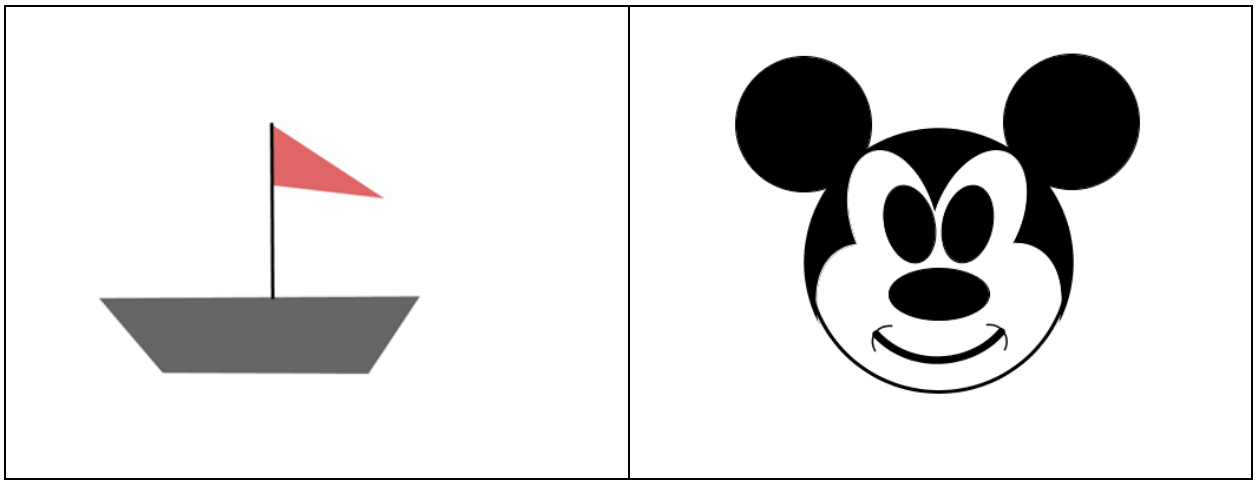

Image 2: GeoGebra was used to create these Images

GeoGebra is free and multi-platform dynamic mathematics software for all levels of education that joins geometry, algebra, tables, graphing, statistics, and calculus in one easy-to-use package (Hohenwarter, Hohenwarter, & Lavicza, 2009). It can be downloaded for free and accessed at: http://www.geogebra.org.The above examples in Image 2 show some drawings students can do with GeoGebra. Students will find using GeoGebra fun and exciting while they learn math as well as allow for some creativity.

GeoGebra was described as raising the enthusiasm for the effective and wise application of technology to the teaching/learning enterprise (Fahlberg-Stojanovska and Stojanovski, 2009; Hewson, 2009). By observing teachers in schools and during the summer workshops, GeoGebra was credited with changing teaching habits. With the availability of dynamic mathematics software, like GeoGebra, teachers are able to make graphical representations of math concepts. As the concepts are introduced with pictorial representations, teachers and their students are able to make the connections between the pictures, the math concepts, and the symbolic representation. When presented with a new concept, students need to think, visualize, and explore relationships and patterns.

Besides GeoGebra, there are many other free online math technology teaching tools (See Appendix B). The Virtual Websites provide great representational understanding for students when learning math concepts at in a positive manner such as using the National Library of Virtual Manipulatives or the National Council of Teachers of Mathematics Illuminations. Both

of these websites are very interactive and used a great deal today in mathematics classrooms. The authors contend that using concrete manipulatives, websites like this that provide representational help, and then going to technologies like GeoGebra can help students transition and advance their mathematical understanding.

Summary

While there are many fearful of mathematics today in our society, using a targeted approach will afford more precise strategies for attenuating students' math anxiety, encouraging more beneficial achievement behaviors for learning math, and inspiring more interest in pursuing careers in math-related STEM fields. In an era of advancing technologies and a push for STEM, it is critical that we address math anxiety and help students develop mathematics confidence. There is a great deal of existing research that supports the use of technology to address math anxiety. One of the best reasons for using dynamic software is that it can even be used for primary-aged students through college, it is fun, easy to use, and students learn a lot about geometry, algebra, measurement and beyond by using this dynamic tool, it can help to prevent and relieve math anxiety and turn young people on to math to explore and feel less intimidated, creating, learning, and having fun while learning mathematics. Math teachers should check for dispositions toward mathematics by using surveys and activities that allow students to talk about how they feel about math. As teachers, we also need to incorporate the best technologies for learning mathematics that can excite and turn students on to math while students create, learn, make sense of, and eventually feel confident in their ability to do math without any apprehension.

References

Alday, R. B., & Panaligan, A. B. (2013). Reducing Math Anxiety of CCS Students through E-Learning in Analytic Geometry. *Educational Research International*, *2*(1), 76-90.

Beilock, S. L., & Willingham, D. T. (2014). Math anxiety: Can teachers help students reduce it? *American Educator*, 38(2), 28-32.

Boaler, J. (2008). *What's math got to do with it? Helping children learn to love their least favorite subject--and why it's important for America*. New York, NY: Penguin Group (USA) Inc.

Buckley, P. A., & Ribordy, S. C. (1982). *Mathematics anxiety and the effects of evaluative instructions on math performance.* Paper presented at the Mid-western Psychological Association, Minneapolis, MN, May 6-8, 1982.

Burkley, M., Parker, J., Stermer, S.P., & Burkley, E. (2010). Trait beliefs that make women vulnerable to math disengagement. *Personality and Individual Differences, 48*(2), 234-238.

ehow Website, (n.d.). Definition of Math Anxiety. Retrieved on December 18, 2013 at: http://www.ehow.com/facts_5666297_definition-math-anxiety.html

Fahlberg-Stojanovska, L, & Stojanovski, V. (2009). GeoGebra- freedom to explore and learn. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, 28(2), 49-54.

Furner, J. M. (1996). *Mathematics teachers' beliefs about using the National Council of Teachers of Mathematics Standards and the relationship of these beliefs to students' anxiety toward mathematics.* (Unpublished doctoral dissertation). University of Alabama, Alabama.

Furner, J. M. (2007) Mathitudes: Research, activities, websites, and children's literature toward a mathematically confident society. Research and activities presented at the National Council of Teachers of Mathematics Southern Regional Conference, Houston, Texas, November 30, 2007.

Furner, J. M. (2009). *Breaking the math anxiety cycle in a multicultural world: Tips and research.* Presentation at the Florida Council of Teachers of Mathematics Annual Fall Conference, West Palm Beach, Florida, October 2, 2009.

Furner, J. M., & Marinas, C. A. (2007). Geometry sketching software for elementary children: Easy as 1, 2, 3. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(1), 83-91.

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom, *Journal of Instructional Psychology, 37*(1), p24-31.

Goldberg, R., & Waxman, J. (2003). A novel approach to curing quantiphobia. *Mathematics and Computer Education,* 37(1), 39-54.

Heitin, L. (2015). Math NAEP scores drop for 4th and 8th grades, *Education Week*, from October 28, 2015, Retrieved from: http://blogs.edweek.org/edweek/curriculum/2015/10/math_naep_scores_drop_for_4th_8th_grades.html?cmp=eml-enl-eu-news2

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21,* 33-46.

Hewson, P. (2009). Geogebra for mathematical statistics. *International Journal for Technology in Mathematics Education*, 16(4), Retrieved May 5, 2011at: http://www.editlib.org/p/30304.

Hohenwarter, J., Hohenwarter, M., and Lavicza, Z. (2009). Introducing dynamic mathematics software to secondary school teachers: The case of GeoGebra. *The Journal of Computers in Mathematics and Science Teaching*, 28(2), 135-46.

Iossi, L. (2013). Strategies for reducing math anxiety in post-secondary students. Retrieved on October 26, 2015 at: http://digitalcommons.fiu.edu/cgi/viewcontent.cgi?article=1257&context=sferc.

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructor in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92*(7), 583-586.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

National Council of Teachers of Mathematics. (1989*). Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). Mathematics anxiety [Supplemental Brochure]. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). Principles and Standards for School Mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (2006). Curriculum focal points for prekindergarten through grade 8 mathematics: a quest for coherence. Reston, VA: Author.

Núñez-Peña, M. I., Suárez-Pellicioni, M., and Bono, R. (2013). Effects of math anxiety on student success in higher education, *International Journal of Educational Research*, Volume 58,36-43, http://dx.doi.org/10.1016/j.ijer.2012.12.004.

Oberlin, L. (1982). How to teach children to hate mathematics. *School Science and Mathematics, 82*, 261.

Ooten, C. (2003). *Managing the mean math blues.* Upper Saddle River, New Jersey: Pearson Education, Inc. of Prentice Hall.

Perry, A.B. (2004). Decreasing math anxiety in college students. *College Student Journal*, *38*(2), 321-324.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: psychometric data. *Journal of Counseling Psychology*, 19, 551–554.

Rosen, D., & Hoffman, J. (2009). Integrating concrete and virtual manipulatives in early childhood mathematics. *Young Children*, 64 (3), 26-33.

Ruffins, P. (2007). A real fear. *Diverse Issues in Higher Education, 24*(2), 17-19.

Scieszka, J., & Smith, L. (1995). *Math curse*. New York: Viking.

Sparks, S. D. (2011). Math anxiety explored in studies, *Education Week, 30*(31), 1.

Strauss, V. (2015). What the national drop in 2015 NAEP test scores really means, *The Washington Post*, from October 28, 2015. Retrieved from: https://www.washingtonpost.com/news/answer-sheet/wp/2015/10/28/what-the-national-drop-in-2015-naep-test-scores-really-means/

Tobias, S. (1993). *Overcoming math anxiety revised and expanded*. New York: Norton Publishing.

Williams, W. V. (1988). Answers to questions about math anxiety. *School Science and Mathematics*, 88(2), 95-104.

Zemelman, S., Daniels, H., and Hyde, A. (2015*). Best practice: Bringing standards to life in America's classrooms* (5th Edition). Portsmouth, NH: Heinemann.

Appendix A:

Mathitudes Survey

Name_____Grade_____

Math Class_____Age_____

Career or Career Interest_____

Mathitude Survey

1. When I hear the word math I _____

2. My favorite thing in math is _____

3. My least favorite thing in math is _____

4. If I could ask for one thing in math it would be _____

5. My favorite teacher for math is _____ because_____

6. If math were a color it would be _____

7. If math were an animal it would be _____

8. My favorite subject is_____ because_____

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

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

Appendix B

Math Anxiety, GeoGebra, and Virtual Manipulative Websites and Resources for the Mathematics Classroom

National Library of Virtual Manipulatives	http://nlvm.usu.edu/
National Council of Teachers of Mathematics	http://www.nctm.org/ccssm/
Cut the Knot	http://www.cut-the-knot.com/Curriculum/
GeoGebra	http://GeoGebra.org
GeoGebra Wiki Forum	https://wiki.geogebra.org/
GeoGebra Data Files	http://matharoundus.com
Math Academy Math Academy	http://www.mathacademy.com/pr/minitext/anxiety/
Mathitudes Online	http://www.coe.fau.edu/centersandprograms/mathitudes/