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Every Student can be an Einstein: Addressing Math Anxiety in Today's Classrooms

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Introduction

"Do not worry about your difficulties in Mathematics. I can assure you mine are still greater."

-Albert Einstein 1879-1955

"I really don't like math, but I do okay." -Julie, 14

"I just don't like math, it's the same thing and big numbers, and I don't like big numbers." -Brian, 13

"I have lots of math anxiety, for me math is very confusing."

-Samantha, 19

"Frustration, sweaty palms, and fear are words I would use to describe what math does to me." -Heather, 34

"When I hear the word math I get goose bumps." -Starry, 9

"Math makes me shake." -Seth, 10

"When I think of math I don't get nervous I get bored."

-Chad, 11

The above comments from students about their feelings toward math are just a sampling of how some young people feel about mathematics in the United States and perhaps around the world. Albert Einstein even was known for sharing his difficulties with math. In Marilyn Burns' book, Math: Facing an American Phobia, Burns (1998) tackles an interesting subject and has found that two-thirds of American adults fear and loathe math. Mathematics anxiety in students has become a concern for our society for many years now. Evidence of students' poor attitudes and high levels of anxiety toward math is abundant (Warwick &

Howard, 2016; Beilock & Willingham, 2014; Warwick, 2008; Geist, 2010; Furner, 1996). In the midst of a technological era, declining mathematics (math) scores on the Scholastic Aptitude Test (SAT) have been widely publicized. Some reports have shown that American students rank last when compared with students from all other industrialized countries on 19 different assessments. The Third International Mathematics and Science Study (TIMSS) has shown a trend in U. S. students' math scores as they decline as students increase in age group from grade four to grade twelve (Schmidt, 1998). What is happening to our students that so many of them lose interest in math and lack the confidence to take more math classes?

Geist (2010) states that negative attitudes toward mathematics and what has come to be known as "math anxiety" are serious obstacles for young people in all levels of schooling today, and he feels that an anti-anxiety curriculum is critical in building students' confidence when working with mathematics especially in the light of a great push for more people going into the fields of Science, Technology, Engineering, and Mathematics (STEM). 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. 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 such high-tech jobs today and in the future. Today, the

United States is working to lead more young people into the STEM fields so we as a country can compete globally. Zollman (2012) believes that we need to evolve from learning for STEM literacy to using STEM literacy for learning to satisfy our societal, economic, and personal needs. If we are to build math confidence in our students, math teachers need to address head on the issue of math anxiety which often manifests itself as hesitancy or learned helplessness in observed math achievement. This paper will look at the issue of math anxiety and provide research based suggestions for preventing and reducing such anxiety in today's classrooms.

Steen (1999) pointed out "national and international studies show that most U.S. students leave high school with far below even minimum expectations for mathematical and quantitative literacy." Neunzert (2000) believes we must understand ourselves as MINT-professionals, where MINT is M=mathematics, I=informatics, N=natural sciences, T=technology. Neunzert (2000) feels that mathematics is critical for people living in the 21st Century for them to be successful. Neunzert believes we need to encourage our students in all countries to study more mathematics and to see it as a tool for success in life.

Teachers today must be equipped to reach all children and develop their confidence and ability to do mathematics. All students really can be like Einstein if teachers really take the time to reach each of them in their unique way. Teachers must check to see that all children have positive attitudes and

dispositions toward math. A great deal of literature like Arem (2003), Curtain-Phillips (2004), Lai (2005), Rossan (2006), and Sheffield & Hunt (2006) show that many people do not like mathematics and there are strategies one can use to develop more math confidence in our young people.

It is critical today that our teachers are well versed on how to effectively teach mathematics so as to address math anxiety in students, develop student confidence in math, and help encourage our young people into careers in the STEM fields. Beilock and Willingham (2014) contend that, "A course on how to teach math concepts seems to be more effective in addressing math anxiety among pre-service teachers than a course on math concepts themselves" (p. 31). Teachers instructing courses with mathematical content at primary, secondary and university level should consider the negative impact of affective factors on teaching/learning processes in mathematics and should incorporate intervention programs in order to mitigate this effect and optimize students' performance (Núñez-Peña, et al., 2013).

It is unfortunately but teachers who are afraid of math may then pass on math anxiety to the next generation by modeling behaviors of their own discomfort with the subject (Furner & DeHass, 2011; Geist, 2010; Reys et al., 2015). How representative are the above comments from young people about math anxieties? A study in 2004 by Perry indicated that 85% of students in an introductory college level math class claimed to have experienced anxiety when

presented math problems. Jackson and Leffingwell (1999) showed another perspective in this study, with only 7% of the college students (N= 157) in their study not expressing math anxiousness. The prevalence of math anxiety in empirical studies is confounding; however, the effect of math anxiety is well documented. 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). Sparks (2011) feels that 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 areas related to STEM. If math anxiety occurs frequently, then attention to the methods that are effective at overcoming math anxiety are important for teacher preparation as well as for in-service math teachers.

Math Anxiety Defined

Math anxiety may be defined as an *"…inconceivable dread of mathematics that can interfere with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations*" (Buckley & Ribordy, 1982, p. 1). NCTM (1989 & 1995) recognized math anxiety as a problem and specifically included in its assessment practices. Standard #10 (NCTM, 1989) prompts teachers to assess their students' mathematical dispositions; such as: confidence in using math to solve problems,

communicate ideas, and reason.

As educators, we need to know what causes this dread of mathematics so that it can be prevented and/or reduced. Causes of math anxiety may vary from socioeconomic status and parental background to the influence of teachers and the school system. Some educators believe that teachers and parents who are afraid of math can pass on math anxiety to the next generation, not genetically, but by modeling behaviors of their own discomfort with the subject. Research by Oberlin (1982) 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.

Ahmed, Minnaert, Kuyper, &van der Werf (2012) examined the reciprocal relationships between self-concept and anxiety in mathematics. A sample of 495 grade 7 students (51% girls) completed self-report measures assessing self-concept and anxiety three times in a school year. The analysis showed a reciprocal relationship between self-concept and anxiety in math (i.e., higher self-concept leads to lower anxiety, which in turn, leads to higher self-concept). Concluding that math self-concept and math anxiety are reciprocally related.

Ineffective teaching practices are not the only cause of math anxiety. A

student's lack of success with math may also be a cause of math anxiety and be 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 is math and what it is not . 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 or learning disabilities. Sheila Tobias, a guru 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). Math anxiety is also prevalent in the population of students with disabilities. Some students in special education have specific math related disabilities; this number is estimated to be between 4 and 7% for school aged students (Lewis, Hitch, & Walker, 1994). There are other students in special education who claim a math disability as a way to cover up anxiety about school in general. Regardless of the student description, engineering students and students in special education alike need a teacher's help to overcome their fears of mathematics and be challenged to take higher-level math courses. Willis (2010), a math teacher and neurologist, in her book, *Learning to Love Mathematics,* gives over 50 strategies you can use right away in any grade level to: (1) Rehabilitate negative attitudes about math; (2) Reduce mistake anxiety; and (3) Relate math to

students' interests and goals. Find out how a better understanding of your students' brains can help you build foundational skills in math and other subjects and develop your students' long-term memory of academic concepts. Explore classroom interventions that help you: (1) Change your students' math intelligences by incorporating relaxation techniques, humor, visuals, and stories into your teaching; (2) Eliminate stress and increase motivation to learn math by using errorless math, estimation, and achievable challenges; and (3) Differentiate your strategies to students' skill levels by using scaffolds, flexible grouping, and multisensory input. Find out how a better understanding of your students' brains can help you build foundational skills in math and other subjects and develop your students' long-term memory of mathematical understanding.

There are things schools can do to help prevent math anxiety from occurring in students. It is a complicated matter and may involve what happens to kids inside and outside of the classroom. Teachers and parents can play a critical role in helping to develop positive dispositions toward math. The NCTM (2000, 1995, 1989) has made recommendations for preventing math anxiety such as:

- accommodate different learning styles
- create a variety of testing environments
- design positive experiences in math classes
- remove the importance of ego from classroom practice
- emphasize that everyone makes mistakes in mathematics

- make math relevant
- let students have some input into their own evaluations
- allow for different social approaches to learning mathematics
- emphasize the importance of original, quality thinking rather than rote manipulation of formulas; and
- characterize math as a human endeavor.

What it comes down to is that teachers must employ "best practices" for teaching mathematics. Zemelman, Daniels, and Hyde (2012) based on a culmination of research have put together what is considered the "best practices" for teaching math which include: (a) use of manipulatives (make learning math concrete); (b) use cooperative group work; (c) use discussion when teaching math; (d) make questioning and making conjectures a part of math; (e) use justification of thinking; (f) use writing in math for: thinking, feelings, and prob. Solving; (g) use problem-solving approach to instruction; make content integration a part of instruction; (h) use of calculators, computers, and all technology; (i) being a facilitator of learning; and (j) assess learning as a part of instruction.

Reducing math anxiety is much different from preventing math anxiety. Teachers almost must take on the role of a counselor to help lower or overcome such anxiety toward math. Recommendations for reducing math anxiety according to Hembree (1990), treatments effective in alleviating math anxiety

include systematic desensitization and relaxation training. Davidson and Levitov (1993) advocate the use of relaxation in conjunction with repeated positive messages and visualizations.

How is math anxiety reduced? Teachers must help students understand how their math anxiety was created. According to Hackworth (1992), the following activities will assist in reducing math anxiety: (a) discuss and write about math feelings; (b) become acquainted with good math instruction as well as study techniques; (c) quality studying; recognize type of information learning; (d) be an active learner and create problem solving techniques; (e) evaluate your own learning; (f) develop calming/positive ways to deal with fear of math and doing math: visualization, positive messages, relaxation techniques, and frustration breaks; and lastly (g) gradual repeated success in math builds confidence. Tobias (1993) suggests that one way for students to reduce math anxiety is to recognize when panic starts, to identify the inactiveness in their analytic and retrieval systems, and to clear up the static without ceasing to work on the problem.

Best Practices to Prevent and Reduce Math Anxiety

Ooten (2003) in her book, *Managing the Mean Math Blues,* outlines a four-step method for managing a persons' math anxiety. Ooten believes that a person who suffers from math anxiety needs to first lay the groundwork by coming to terms with their feelings and challenge their current beliefs and realize they are not alone; second, one must change their thoughts and negative thinking

and use intervention strategies to improve one's thinking that they can be successful at math; third, one needs to know thyself, it is important that one knows his/her learning style/mode and that he/she apply approaches to doing math by successful people; and lastly fourth, once one has gained some confidence and strategies for doing mathematics they then must apply what they learned and actually do the math. All of Ooten's techniques require the teacher to first be aware and second to support the student in turning around their anxiety. When a student essentially acknowledges that "I'm not good at math and so I never will be", it has dangerous implications for students' motivation (Dickerson, 2013). In a study of over 3,000 students from elementary to high school, researchers found that where a student's motivation came from made a difference. Students who wanted to get better at math to learn more about the subject (mastery-approach goal) ended up improving more than those who were focused on just getting a good grade (Dickerson, 2013). Recommendations for motivational strategies that may be useful in preventing and reducing math anxiety and improving attitudes toward learning mathematics include: making mathematics relevant, highlighting that everyone can make mathematical mistakes while still having the capacity to improve, engaging students in their own self-evaluations, and reducing the importance of ego from classroom practice (Finlayson, 2014; NCTM, 1995).

Some Practical Examples of What Teachers can do in their Math Classrooms to address Math Anxiety: Tried and True

#1. Journal writing in math classrooms has become an everyday event for many students. Students use journals to express their understanding of mathematical concepts. Journals can also be used to allow students to share feelings and experiences with math. Students are rarely asked how they feel about learning about different concepts and branches of mathematics. Teachers can get a better understanding and feel for any frustration student are feeling. The following sample list of journal/discussion question may be used for students to write about alone or to discuss and share together as a class. Teachers must realize that for students to overcome or have their math anxiety reduced, they must first initiate this form of therapy by allowing students to express their true feeling about math and how they arrived at such a disposition:

Journal/Discussion Questions for Students

1. Pretend that you must describe mathematics to someone. List all the words or phrases you can think of that you could use.
2. Describe how you feel in a math class.

#2. Another practical idea for teachers and students is for teachers to assess their students' dispositions toward math at the beginning of a school year by having them complete the following Mathitude Survey:

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_____.

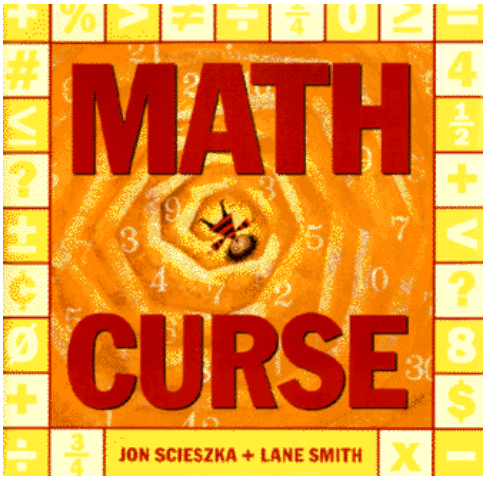
7. If math were an animal it would be_____.

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.

(This survey is great to use toward the beginning of the school year to assess students' feelings toward math and level of anxiety.)



#3. The picture book, *Math Curse* (Scieszka & Smith,1995), addresses the issue of math anxiety. It is an excellent example of how educators have come to terms

with the fact that not all people feel confident in their ability to do math. When Mrs. Fibonacci, an elementary school teacher, tells her class that they can think of almost everything as a math problem, one student becomes overwhelmed by the scope of math. This math anxiety becomes a real curse. However, the student eventually realizes that math is everywhere and there is no way of escaping it in daily life; therefore, the math anxious youngster recognizes math as a means of making one's life easier. This book may be used as a form of bibliotherapy to prompt discussion on the topic of math anxiety and allow other students to discuss their feelings on the topic to compare to the character in the book. Hebert & Furner (1997) have found bibliotherapy effective in reaching the math anxious and provide lessons and activities in their work.

#4. Read and Discuss the Following Statements from Famous People/Build Confidence and believe that your Students can succeed at Math

Furner and Grace (2016, p. 1) discuss in their paper how it is important to share stories with both students and parents alike so that they realize that all things are possible, they state and share:

"SOMETHING TO THINK ABOUT:
***Beethoven's music teacher once told him that as a composer, he was hopeless!
***Walt Disney was fired by a newspaper editor because he had "no good ideas."
***Winston Churchill failed sixth grade.
***Louisa May Alcott was told by an editor that she'd never write anything with popular appeal.
***As a boy, Thomas Edison was told by his teachers that he was too stupid to learn anything.
***Einstein was four before he could speak and seven before he could read.

YOUR ASSIGNMENT:

****Read the previous statements every time you think your child is a little different or not being quite what "we" WANT THEM TO BE. Maybe their goals are a bit higher. Maybe, just maybe, they have a different way of reaching their own standard of excellence."

Furner and Grace (2016) in their paper talk about how important it is to makes sure that your students and their parents know that in your class all students will succeed. Grace believes that there are five powers children need. The need to: perceive, interpret, want, feel, and express. Grace feels that this can happen when children's basic needs are met which include: security, self-worth, self-value, strokes, stimulation, and structure. Grace repeats constantly, "You know what ever I'm going to teach, you are going to learn." Grace says, "They believe that I can teach them math." (Page 1.) When teachers believe all children can learn and the children know that the teachers believe this truly, then students really can succeed beyond most expectations. This is a real key component to effective teaching and learning.

A Summary and Resources for Math Anxiety

What NCTM says about Mathematics Anxiety and Dispositions Toward Mathematics

Standard 10: Mathematical Disposition

As mathematics teachers, it is our job to assess students' mathematical disposition regarding:

*confidence in using math to solve problems, communicate ideas, and reason;
*flexibility in exploring mathematical idea and trying a variety of methods when solving;
*willingness to persevere in mathematical tasks;
*interests, curiosity, and inventiveness in doing math;
*ability to reflect and monitor their own thinking and performance while doing math;
*value and appreciate math for its real-life application, connections to other disciplines and cultures and as a tool and language.

Visit the Mathitudes Website at: http://www.coe.fau.edu/centersandprograms/mathitudes/

How to Reduce Math Anxiety in a Nutshell

1. Psychological Techniques like anxiety management, desensitization, counseling, support groups, bibliotherapy, and classroom discussions.

2. Once a student feels less fearful about math he/she may build their confidence by taking more mathematics classes.

3. 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.

How to Prevent Math Anxiety in a Nutshell

1. Using "Best Practice" in mathematics such as: manipulatives, cooperative groups, discussion of math, questioning and making conjectures, justification of thinking, writing about math, problem-solving approach to instruction, content integration, technology, assessment as an integral part of instruction, etc.

2. Incorporating the *Common Core* and *NCTM Standards* and other State Standards into the curriculum and instruction.

3. Discussing feelings, attitudes, and appreciations for mathematics with students regularly

The recommendations from the National Council of Teachers of Mathematics are words to the wise. The key to all the NCTM recommendations is to plan wisely and make the instruction welcoming for students. A lesson that engages students with all types of learning styles and learning needs sends a message to everyone in the class that the expectation is for all to be successful. The same is true for a teacher who includes in his lesson plan time to talk about different ways to solve a problem. This underscores, as NCTM advises, that there

are different social approaches to learning math, not just the one in the text. Prevention of math anxiety is all about teacher planning and using the best possible practices in math instruction. As mentioned, Geist (2010) feels that negative attitudes toward mathematics and what has come to be known as "math anxiety" are serious obstacles for young people in all levels of schooling today. In his paper, the literature is reviewed and critically assessed in regards to the roots of math anxiety and its especially detrimental effect on children in "at-risk" populations such as, special education, low socioeconomic status, and females, he feels that an anti-anxiety curriculum is critical in building students' confidence when working with mathematics.

Working from the academic perspective, Zemelman, Daniels, & Hyde (2012) and Furner, Yahya, & Duffy (2005) have compiled evidence based practices for teaching math which include: (a) use of manipulatives (make learning math concrete); (b) use cooperative group work; (c) use discussion when teaching math; (d) make questioning and making conjectures a part of math; (e) use justification of thinking; (f) use writing in math for: thinking, feelings, and problem solving; (g) use problem-solving approach to instruction; make content integration a part of instruction; (h) use of calculators, computers, and all technology; (i) being a facilitator of learning; and (j) assess learning as a part of instruction. Each of these best practices make math more "accessible" to students

who enter the math instruction situation with trepidation. The first step in such an important educational goal is to understand effective ways to reduce math anxiety and encourage more positive attitudes for learning mathematical concepts. If the goals students adopt have some relationship to beneficial achievement behaviors and a healthy outlook for learning math concepts, we can then consider how the research literature outlining suggestions for creating mastery-oriented classrooms may also help to reduce the anxiety students experience during mathematics instruction (Furner & Gonzalez-DeHass, 2011). 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 areas related to STEM (Sparks, 2011). In this effort, educators can encourage students to develop productive mathematical dispositions, be more willing to take risks and share their ideas, and come to see they can improve through effort and good study habits, so that they are prepared for future schooling and eventual careers (Dickerson, 2013; Quander, 2013).

Summary

Math teachers can do many things mentioned in this article in their classrooms to help prevent and reduce math anxiety helping their students gain confidence and become mathematical like Einstein. Teachers can also work with school counselors as well as encourage their schools to have family math nights where parents come with children and together they can "do" math and see its

importance and value in life. As a society, we must work together to extinguish this discomfort our students have toward mathematics. It is important that our students in the U.S. feel confident in their ability to do mathematics in an age that relies so heavily on problem solving, technology, science, and mathematics. It is a teacher's obligation to see that their students value and feel confident in their ability to do math, because ultimately a child's life: all decisions they will make and careers choices may be determined based on their disposition toward math. Teachers must make the difference in our students' attitudes toward math! We need to make sure all our students have the capability to become an Einstein and feel confident in their ability to pursue fields like science, technology, engineering, and/or mathematics so to better compete and be successful in this high-tech world we live in. It is our job as math teachers to make sure all our students see success with mathematics and like it too. All students can be Einstein if math teachers take the time to implement best practices outlined in this paper.

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