

## Improving the Mathematics Learning Experience while Assuring STEM Confidence

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*Teachers today need to really focus on the math learning experience of their students. It is critical that as educators we inspire the desire to learn, motivating students and building confidence and interest in learning math. Mathematics teachers may at times take on the role of counselors to address the math anxious in their classrooms. Today math anxiety is real and is a factor in attracting young people to many STEM fields. By the time many young people reach middle school, they have developed certain dispositions toward mathematics. What strategies will lessen the negative disposition and anxiety many students have toward math? The strategies included in this article are applicable to all learners. It is important that all students feel confident in their ability to do mathematics in an age that relies so heavily on problem solving, technology, science, and mathematics. In a STEM world it really is a school's obligation to see that their students value and feel confident in their ability to do math, because ultimately, all decisions individuals make and choices of careers may be determined in part by their confidence toward math. Math teachers today can assure confidence for STEM in their students by addressing the mathematics learning experience and employing all the best practices to address math confidence in their students.*

**Keywords:** Math Learning Experience, Math Anxiety, Motivation, Confidence, Strategies, STEM

### Opening Premise

*From the very beginning of his education, the child should enjoy the joy of discovery.*

-Alfred North Whitehead

Aristotle observed that “All men by nature desire to learn.” While all people learn at a different degree, what really often makes a difference is the teacher spurring the desire to learn. Not only do teachers convey knowledge, if they are superior, they should also be stimulating a desire to learn. This paper will look at the math learning experience and share some insight into motivating students mathematically while addressing math anxiety and teaching to better reach all students for the STEM world we now live in. The British Mathematician, Alfred North Whitehead, observed how important it was that students enjoy learning mathematics. As educators today, we often see many students who are afraid of or have had bad experiences with learning mathematics.

Many young people today are quick to say they do not like mathematics. A negative

attitude toward math in their students causes some math teachers to assume the role of counselors, motivators, and even cheerleaders in their classrooms to address the needs of students who dislike or are fearful of mathematics. When it comes to statistics or even mathematics in general, students unfortunately do not leave their K-12 classroom with a positive mind-set concerning math and math instruction. Tomasetto et al. (2021) found that mathematics unease interferes with learning novel mathematics contents in early elementary school. As Stoehr (2019) points out that math anxiety can begin with elementary-aged students and if not corrected and addressed early can be carried with them for life. Many leaders and advocates for STEM often neglect to realize that the one major reason so few people go into STEM fields is because their lack of confidence in doing mathematics, many people today have math anxiety, preventing them from pursuing STEM areas as careers. Nunez-Pena et al. (2013) found that university students who demonstrated mathematical anxiety and negative attitudes toward math also demonstrated lower performance scores in a university research design course. This finding is interesting given

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the reality that Research Design is typically taught as a non-numerical course, rather a problem-solving course that would involve math concepts. Skagerlund et al. (2019) found in their research that math anxiety leads to an impairment of a student's working math ability. 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 fields of Science, Technology, Engineering, and Mathematics (STEM) so we as a country can compete globally. 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 may require teachers to be much more than counselors, motivators, and cheerleaders to change math attitudes; they need to consider how they THINK about teaching math to lessen the anxieties often connected to mathematics instruction. Choe et al. (2019) found in their research that greater levels of math anxiety were linked with a propensity to select easier, low-reward problems over harder problems. They contend that addressing this robust math anxiety-avoidance connection has the possibility to increase interest and success in related STEM fields. This paper looks at the math learning experience while in school and strategies teachers can employ to address math confidence so that students are ready for any STEM field.

### **Math Apprehension Does Exist and it Affects the Math Learning Experience**

Mathematics teachers hear each day from their students that they do not like math. Today our young students readily volunteer a litany of stories about how bad they are at math and what a hard time they had in previous classes. Many have had bad experiences and dislike math because of previous teachers or just not being able to "get it." Research from Furner (1996) shares the following about a math anxious youngster:

Brian said, "I just don't like math, it's the same thing and big numbers. I don't like big numbers." "I hate it!" were the words that Brian first used to describe math during our initial interview. Brian is a quiet and shy seventh grader. He is small and the type to wear an oversized "starter" jacket. During our first interview, he

seemed a little uncomfortable talking to me about his feelings about math. I offered him some candy each time to calm him down and did the same in later interviews. Brian sits in the second seat from the front near the center. He said that they have assigned seats. Brian feels he can easily make an A in science. He likes the abundance of "neat experiments" in science, although he feels that the information taught is sort of pointless for people to learn. Brian feels that both math and English are intimidating. In this case study of Brian, the following themes will be the focus: past and present experiences with math; anxieties, feelings, and attitudes about math; things teachers can do in a math class; homework and study habits used; and an analysis of the findings. The case study will provide some direct quotes from him that will hopefully provide insights into the student's math anxiety and what teachers can do to alleviate such anxiety.

Brian says that he is not the type of person to do well in a math class. Brian said that "kindergarten and first grade were easy; second, third, and about the past 5 years I haven't liked math." He told me that in first and second grade, math was easy, and they played many math "games." He liked math. Brian said that one of the main reasons why he disliked math from second grade through fifth grade was because of the "long numbers." He said that there were too many "big numbers" and it "took a long time" to work out the problems; he said that he really hated this. Brian said that sixth-grade math was a little better, and the teacher taught using more "games." Brian told me during our last interview that he thought he was "beginning to like it more." I asked him whether he felt that our conversations about math and his feelings toward the subject had any influence on how he currently felt toward math. He told me he was starting to like math more and felt that our conversations had helped to improve his attitude toward the subject.

Brian said math is "boring." Math is just "using a bunch of numbers." He said math does not make him nervous except when he is not paying attention.

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Brian's analogies for math were that math would be the color black if it were a color, math would be a wolf if it were an animal, because math is vicious and nasty, math would be classical music, and he doesn't like classical music, and math would be spaghetti if it were a food, but he didn't know why he picked spaghetti. Brian said that yes, he does feel nervous in math. Why? "Because I have to do certain things. Like talking in class." Brian says what makes a person good in math is that "they study really hard, they ask questions, they do their homework, and they get straight A's." Brian says he is not a good math student, and that he studies just a little bit. Brian scored at the 35th-percentile level on the attitude inventory on math problem solving. He was quiet answering some of the questions because his math teacher happened to be in the room at the time of the interview. He really does not seem to like math and lacks confidence. He feels that he does not work a long time on a problem, he is not as good as others, and that he cannot solve most problems. He does not feel that he is a good math problem solver. But, "I don't feel like I have math anxiety," says Brian. Brian told me during our third interview that he is at ease in his math class if he is not called on. He told me that his seating arrangement in class had changed and that he was now sitting in the back of the room. He said that this relieved his math anxiety somewhat because his is no longer called on as often.

Brian said that to him a good math teacher is one who "goes over it until you get it." He likes his math teacher to teach in a quiet environment, with little talking taking place. Brian says that he likes his math teachers to use blocks and chips; he said, "yeah, I like using them; I like hands-on things." He said that past teachers have used such manipulatives. He said that teachers can use "games" to make learning math more fun without feeling nervous or making you dislike math. Brian said that he didn't think it was a previous teacher or anything else that made him not like math; he said it was "big numbers." He said, "It is the same thing, and big numbers."

Brian said that he spends about 15 minutes a day doing math homework on average. He said that homework helps him to understand the concepts better. He said that "homework helps to bring your grades up." He said, "I sit down in a chair and start doing it." He works on his homework until he gets frustrated. He says, "If I don't understand it at all, I just quit." He did say he goes back to it after he has had a little break--this was one way he coped with his frustration. Brian said that he does not usually study for math tests, and that his dad usually helps him with his homework. "Usually my dad; my mom helps if my dad is at work. When I was younger, my mom and dad helped."

Brian does feel that "we do need to learn math." He said, "Yes, because you are going to use it in everyday life, checks, bills." He felt that it is important to be introduced to math while in school. Brian said he liked word problems with "words and numbers mixed in." He said that it helped him better to understand math problems if they contained both words and numbers. Overall, Brian seemed to have a dislike for math and did not feel comfortable in the way it was taught or dealing with big numbers. Brian told me that even though he studies for math, math still seems a little bit hard.

In an overall analysis of Brian, it was apparent throughout all three interviews with him that he has not been successful with mathematics. First and second grades were the only years that he felt that he had any success with mathematics. From second grade on he has continued to struggle with failure. He does not like to be called on in math class and would prefer not to participate. He really does not study much nor give much effort, as he has resolved himself to the fact that he is a failure. One main aspect of his failure deals with test taking. Brian has not learned on his own, from teachers, or from his parents any techniques or methods for succeeding at math. His self-confidence about doing math appeared to be extremely low throughout each interview. He said math is okay if small manageable numbers are used in the problems and if

there are not a lot of problems to do at any one sitting. He mentioned how in fourth grade he was forced to do long division problems with "big numbers" and that this took him a long time to do and really turned him off to mathematics altogether. Many words may describe Brian: bored, angry, unconfident, quitter, and frustrated. Brian feels that none of his teachers thus far have touched him mathematically. Brian does not feel that he is smart enough for math and describes math as his worst subject." (P. 101-107)

How representative are the feelings toward math from young people today? Do many of our young people feel like Brian does about mathematics? There are many studies that have been done related to mathematics apprehension. 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 (dos Santos Carmo et al., 2019; Haase et al., 2019; Ramirez et al., 2018). Dowker et al. (2019) found that even students form poor attitudes toward math at very young ages in their first years in school based on success with arithmetic early on. Klee and Miller (2019) found that even as students advance in age from elementary to middle school and upward, students can bring such negative feelings about math with them and it can influence future choice and motivation toward studying the subject as they progress throughout various grade levels. 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; Steen, 1999). 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. Today with the push to educate using the Common Core State Standards

(CCSS) (National Governors Association, 2010) math teachers are challenged to reach all students with much higher and rigorous levels of mathematics for US students. Educators today really need to work a lot harder to break the cycle of dislike and discomfort with learning and doing mathematics to better prepare young people for the STEM fields.

### How Do We Define Math Anxiety?

Math anxiety can 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, see appendix A) prompts teachers to assess their students' mathematical dispositions; such as: confidence in using math to solve problems, communicate ideas, and reason mathematically. Math unease is often caused by a combination of external and internal factors; however, we cannot change internal factors within the student, so as teachers it makes more sense to focus on what we can control (Chernoff & Stone, 2014). Math unease is a well-documented phenomenon that has affected our society for over sixty years, and not enough is being done to address it in our classrooms or in the way we teach math (Furner & Duffy, 2022; Furner, 2019; Beilock & Willingham, 2014; Boaler, 2008; Dowker et al., 2016; Geist, 2010; Metje et al., 2007, NCTM, 1995). Negative attitudes toward mathematics and math anxiety are serious obstacles for students in all levels of schooling today (Geist, 2010). Beilock and Willingham (2014) state that "Because math anxiety is widespread and tied to poor math skills, we must understand what we can do to alleviate it" (p. 29).

Math teachers need to know what causes this dislike of or discomfort with 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 worry 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)

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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.

Poor teaching practices are not the only cause of math anxiety. Parents may also play a factor as well as other issues. 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 math is 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 are 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 et al., 1994). Often there are other students in special education who claim a math disability 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) 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.

### **Addressing Math Unease During the Learning Experience**

For the reason that math anxiety can be seen in daily living activities as well as in class work or assignments, the need to have a multi-pronged approach is crucial to addressing it. Applying anxiety-lessening techniques in a variety of activities and frequently throughout instructional activities helps to address a variety of student needs. This is like the idea of applying different management and organizations skills suited the situation. As Skagerlund et al. (2019) found that math anxiety can impair math ability, they suggest students need to learn strategies to manage this so that it is not affecting their working memory and number processing when they do math. Applying different techniques prior to teaching a math activity allows the teacher to set a more focused and less anxious tone for a math activity. Again, applying techniques that lessen anxiety and provide support just prior to beginning the math activity, as well as when the activity help cue the anxious students to a more positive approach to math class work. Taking a cue from classroom management practices (Furner and Duffy, 2002), the next section of this paper explains how: to apply specific strategies to prevent math anxiety while planning for a math activity; to support positive math attitude just before teaching a math activity; and to assist or redirect a student when they get off track from a positive math attitude is critical in developing mathematically confident students ready for STEM field careers.

### **Math Anxiety Intervention**

Math teachers can employ many strategies in schools to help prevent math anxiety in students. 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. The field of math education has recently made the push to increase and encourage math literacy, and along with that push has developed some useful materials to encourage math competence. Mammarella et al. (2018) found in their research that it is important as educators to separate the math from the anxiety and in their

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research results, they found that children with severe math anxiety, but with no developmental dyscalculia were specifically impaired in the proactive interference task, while children with developmental dyscalculia (with or without math anxiety) failed in the working memory tasks. Their findings argue for the importance of distinguishing the cognitive processes underlying the profiles of a child, which may have factors as educators address preventative and reduction tactics as it relates to math anxiety. One program developed by the Southeastern Consortium for Minorities in Engineering (SECME) is used in schools with high minority populations to motivate and get students interested in math, science, and engineering. SECME was originally an acronym for *Southeastern Consortium for Minorities in Engineering*. SECME is a nonprofit organization originally established in 1975. The organization is based out of Atlanta, Georgia at the Georgia Institute of Technology. SECME is a strategic alliance to renew and strengthen the professional capacity of K-12 educators, motivate and mentor students, and empower parents so that all students can learn and achieve at higher levels. (SECME, n.d.) Many teachers find this program very useful to turn young people on to math and motivate them to like math more. The elementary and middle school years are critical to developing positive perceptions toward mathematics in children. The NCTM (2000, 1995, & 1989) provided recommendations for preventing math anxiety with recommendations and as summary is presented in Table 1 below:

**Table 1: NCTM Recommendations for Preventing Math Anxiety**

- 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

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- Characterize math as a human endeavor (NCTM, 1995)

NCTM's recommendations for math teachers are words to the wise for educators in employing best practices in the classroom. We have turned the NCTM tactics into a short lesson plan/unit checklist that can be used to check the "Mathitudes Survey" of a lesson or unit. 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. These 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 (dos Santos Carmo et al., 2019). The way we fix math anxiety in our schools. To put it simply: better teaching. Finlayson suggests the constructivist style of teaching which emphasizes these ideas:

- "Begin with the whole – expanding to parts
- Pursuit of student questions/interests
- Primary sources/manipulative materials
- Learning is interaction – building on what students already know
- Instructor interacts/negotiates with students
- Assessment via student works observations, points of view, and tests. Process is as important as product
- Knowledge is dynamic/change with experiences
- Students work in groups" (Finlayson, 2014)

### **Lessen Math Nervousness**

Lowering and eliminating math anxiety is much different from preventing math anxiety. While every educator would like to prevent a student from experiencing math anxiety, some come to school already worried about being skilled at math. Many have had previously bad experiences with prior math teachers. Ooten (2003) in her book, *Managing the Mean Math Blues*, outlines a four-step method for managing

a persons' math anxiety. Ooten contends 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 Ooten's techniques require the teacher to first be aware and second to support the student in turning around their anxiety. Another problem for those who suffer from math anxiety is the nature of anxiety itself. According to Rubinstein et al. (2015), anxious individuals tend to focus on negative stimuli more than positive stimuli, essentially making themselves more anxious. The same thing is true of individuals with math anxiety; the only difference is that for people with math anxiety, math is the negative stimuli (Rubinstein et al., 2015). This suggests that math anxiety could be handled through therapies designed to lessen anxiety, such as cognitive behavioral therapy and exposure therapy (exposing a person little by little to that which they are afraid which employs counseling techniques) (Rubinstein et al., 2015).

Supportive techniques play out in a variety of ways in counseling settings while teaching help to start the process of coming to terms with such discomfort. For example, some researchers (Furner, 1996; Hembree, 1990; Olson & Gillingham, 1980; Ramirez et al., 2018; Schneider & Nevid, 1993; Trent, 1985; all propose systematic desensitization as an effective approach for helping people reduce their math apprehension. Systematic desensitization in the context of math anxiety may be defined as a gradual exposure to the mathematical concepts that are causing students to become distressed and teaching them how to cope with that fear. Through systematic desensitization, a common practice in counseling, students come to understand that their anxiety is a learned behavior, one they were not born with, and they can be taught to overcome it by consistently implementing their self-monitoring strategies to become less anxious. Other researchers, Davidson and Levitov (1999) advocate the use of relaxation in

conjunction with repeated positive messages and visualizations to reduce math anxiety.

Math teachers must help students understand how their math anxiety was created in the first place. 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 (g) gradual repeated success in math builds confidence (See Appendix A). Tobias (1987) 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.

By working from an academic perspective, Zemelman et al. (2012) and Furner et al. (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 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. Also, see Appendix A for a summary, which includes strategies/key ideas for overcoming/preventing math anxiety. Each of these best practices make math more "accessible" to students who enter the math instruction situation with trepidation. These best practices can better foster a new experience for learners who in the past felt less than comfortable with mathematics.

### **Building Math Confidence and Motivation**

Math teachers along with the school counselors, special education teachers, and other specialists can work together to do many things in classrooms to help build their students math confidence. One real-world idea for teachers and students is for teachers to assess their students' dispositions toward math at the

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beginning of a school year by having them complete the following *Mathitude Survey* (Furner, 2007):

Mathitude Suvery

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.....

Writing in math journals in a math classrooms during instruction has become an everyday event for many students today. Students use journals to express their understanding of mathematical concepts. Journal writing 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 really get a better understanding and feel for any frustration student are feeling and can be a corrective strategy for helping student develop math confidence and deal with any previous math anxiety.

Included is a 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 as a corrective strategy, students to express their true feeling about math and how they arrived at such a disposition:

Journal/Discussion Questions for Students in Groups

1. Pretend that you must describe mathematics to someone. List all the words or phrases you can think of that you could use.
2. Imagine yourself doing or using math either in or out of school. What does doing \_\_\_\_\_ or using \_\_\_\_\_ math feel like? Describe.
3. If math were a color, an animal, music, or food what would it be?
4. For me math is most like. Why?
5. Describe how you feel in a math class.

6. Are you the type to do well in math class? Why or why not?

*Math Curse*, (Scieszka and Smith, 1995) is a picture book which 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. His 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. *Math Curse* 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. Isdell (1993) wrote another great book, *A Gebra named Al*, about a young girl who struggles with her feelings toward math at the middle school level. This is also a wonderful book to incorporate in a bibliotherapy lesson to address math anxiety with students.

Using books, or bibliotherapy, to assist in teaching and addressing psychological concerns like math anxiety is now a common practice. Hebert and Furner(1997) outline specific lessons and activities to help in reducing math anxiety with activities such as: role playing feelings and experiences with math classes/teachers; using a math journal for students to write in, so they may describe their feelings while doing math problems, writing letters to the main character of the book *Math Curse* (Scieszka and Smith, 1995) writing math anxiety poems and rap songs about math and/or their anxiety toward mathematics; writing a letter to Anne Landers or Dear Abby about their math anxiety; designing anti-math anxiety bumper stickers to be plastered on their school lockers, providing students with a daily self-affirmation statement; providing students an opportunity to create original radio or television advertisements for a national anti-math anxiety campaign; and providing students an opportunity to select an artistic medium (i.e. magazine photo collage, penciled sketch) to illustrate their math anxiety to name a few. Hebert and Furner feel that teachers need to take the time in their math instruction to address such affective aspects of learning mathematics so that students can come to terms with their feelings toward mathematics (Furner, 2018).

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The researchers Jackson & Leffingwell (1999), found that only seven percent of the population in their study reported having positive experiences with mathematics from kindergarten through college. The study cited that there are many covert, as well as, overt behaviors exhibited by the math instructor in creating math anxiety in students. Things like difficulty of material, hostile instructor behavior, gender bias, perceptions of uncaring teacher, angry behavior, unrealistic expectations, embarrassing students in front of peers, communication and language barriers, quality of instruction, and evaluation methods of the teacher. Math instructors' behaviors and teaching methods can be hurtful and negative to students learning math. Math teachers need to take an active role in reducing performance anxiety in math. It is not uncommon that a student will say, "I like the class because of the teacher." It is often because the teacher knows how to present developmentally the subject matter, creates a learning environment conducive to learning with compassion, has high expectations for all students without regard to gender, race, or language barriers, and uses a variety of assessment methods and teaching styles to better reach all students. It is the teacher's obligation to see that all students are prepared for a high-tech society where one cannot afford to not feel confident in their ability to do math, math teachers need to use corrective strategies to support students' math anxiety and help them work toward becoming more confident in doing mathematics. Geist (2010) feels that negative attitudes toward mathematics and what has come to be known as "math anxiety" are serious obstacles for children 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. Such a protocol can assist students in building confidence in mathematics and ready them for STEM fields, one protocol is outlined in Higgins et al. (2020).

### Concluding Supposition

Mathematics teachers today can assure that their students are confident in their ability to do mathematics and ready them for our STEM world when they put safeguarded strategies mentioned in this paper to practice. Math

teachers need to look deeper at their students' needs and address the math learning experience of their students in their classrooms as they teach the subject. Math anxiety is not limited to any one group of students. Teachers today need to address motivation, desire to learn, and be experts in using best practices to teach math to better reach all students for STEM careers. It is helpful to understand that motivating students and solving math anxiety is not a one-shot practice, rather it requires considerations and accommodations in the planning stages, during the lesson and then again if the anxiety becomes evident during the lesson or while doing homework. Today it really is a teachers' responsibility 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 outlook toward mathematics. As mathematics educators we must make the difference in our children's' attitudes toward math and be sure to address this during the math learning experience while in school K-12. It would be nice to hear more young people and adults when asked how they feel about math say, "Math is my favorite subject" or "I am great at statistics!" or "I can solve any word problem!" Math teachers need to build confidence and use more best practices outlined in this paper to better reach all students so to produce more mathematically confident young people for the 21<sup>st</sup> Century in this STEM world we are now living in. As a society we should want all young people to experience the joy of learning mathematics and feel confident to explore any STEM career they see fit when they finish their K-12 schooling.

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## Appendix A: Standards and Strategies to Address Math Anxiety

### *Improving the Mathematics Learning Experience*

#### **What NCTM says about Mathematics Anxiety and Dispositions Toward Mathematics**

##### **Standard 10: Mathematical Disposition (NCTM 1989)**

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.

#### **A Synthesis on How to Reduce Math Anxiety**

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 (Furner, 2007)

#### **A Synthesis on How to Prevent Math Anxiety**

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 NCTM *Standards* and your State Standards into curriculum and instruction.
3. Discussing feelings, attitudes, and appreciation for mathematics with students regularly (Furner, 2007).