

Addressing Math Anxiety in a STEM World: Preventative, Supportive, and Corrective Strategies for the Inclusive Classroom

Joseph M. Furner ^{1*}, Mary Lou Duffy ¹

¹ Florida Atlantic University, UNITED STATES

*Corresponding Author: jfurner@fau.edu

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ABSTRACT

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 for both general and special education teachers, especially when used together to prevent and reduce math anxiety. 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 attitudes toward mathematics.

Keywords: inclusion, math anxiety, strategies, reduction, STEM

INTRODUCTION

Children are not limited in what they can do when they have mathematics skills because to a mathematician, “real life” is a special case.

-Author Unknown

It is peculiar that individuals who cannot read are often ashamed of this; however, many individuals are quick to admit that they are not good at math or do not like it. A negative attitude toward math 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. 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. Núñez-Peña 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 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 students working math ability. As Boaler (2008) points out, it is critical to ensure 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 will look at the issue of math anxiety and provide research-based suggestions for preventing and reducing such anxiety.

Issue-Problem Statement-The Truth is that Math Anxiety does exist in our World

As math teachers, we hear it all the time when 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.” Some voices from young people about mathematics include the following:

“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 goosebumps.”--Starry, 19

“Math makes me shake.”--Seth, 13

“When I think of math I don’t get nervous I get bored.”--Chad, 14

How representative are these comments from young people about their 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 (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 varies 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). Sparks (2011) feels that as the STEM fields becomes 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.

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 and 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 anxiety 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 and Stone, 2014). Math anxiety 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 (Beilock and 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).

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.

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 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.

MANAGING MATH ANXIETY

Because 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 organization 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 BEFORE 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

Table 1. NCTM recommendations for preventing math anxiety (NCTM, 1995)

| No | Recommendation |
|----|---|
| 1 | Accommodate different learning styles |
| 2 | Create a variety of testing environments |
| 3 | Design positive experiences in math classes |
| 4 | Remove the importance of ego from classroom practice |
| 5 | Emphasize that everyone makes mistakes in mathematics |
| 6 | Make math relevant |
| 7 | Let students have some input into their own evaluations |
| 8 | Allow for different social approaches to learning mathematics |
| 9 | Emphasize the importance of original, quality thinking |
| 10 | Characterize math as a human endeavor |

prior to beginning the math activity, as well as DURING 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 CORRECT 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. The following proposed methods to break the math anxiety cycle include the following preventative, supportive, and corrective steps to chart as follows:

Prevention Tactics: Planning to Diminish Math Anxiety

There are many things schools can do to help prevent math anxiety. 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 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**.

The recommendations from NCTM are words to the wise for mathematics teachers. We have turned the NCTM tactics into a short lesson plan/unit checklist that can be used to check the “Mathitudes” 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).

Supportive Tactics: Reducing/Overcoming Math Anxiety

Reducing 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. 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 Rubinsten 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 (Rubinsten 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) (Rubinsten et al., 2015).

We can see these support techniques played out in a variety of ways in counseling settings. For example, some researchers (Furner, 1996; Hembree, 1990; Olson and Gillingsham, 1980; Ramirez et al., 2018; Schneider and Nevid, 1993; Trent, 1985); all propose systematic desensitization as an effective approach for helping people reduce their math anxiety. 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.

How is math anxiety reduced in the classroom setting? 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.

Working from the 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.

Corrective Tactics: Working on Building Math Confidence

Teachers and specialists can work together to do many things in classrooms to help build their students math confidence. One 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* (Furner, 2007):

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

Journal writing in math classrooms has become an everyday event for many students. 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.

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 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?

The picture book, *Math Curse*, (Scieszka and 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. 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.

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.

In a study by Jackson and Leffingwell (1999), they cited 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.

SUMMARY

Teachers of mathematics need to look deeper at their students' needs and address the math anxious students they have in their classrooms. While some of these math anxious students will be students with special needs, math anxiety is not limited to that group alone. By working with school specialists like special education teachers, inclusion support specialists and school counselors, classroom teachers will find support for themselves as well as their students. These specialists can provide both emotional and academic support strategies for the teachers first when they plan lessons and units and later as they teach those lessons. It is helpful to understand that 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. It really is a teachers' 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 mathematics. As educators we must make the difference in our children's' attitudes toward math. 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 stats!" or "I can solve any word problem!" Through math confidence building sessions with the teacher and counselor, schools can produce more mathematically confident young people for the 21st Century.

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APPENDIX A: STANDARDS AND STRATEGIES TO ADDRESS MATH ANXIETY FOR ALL STUDENTS

Standards and Strategies to Address Math Anxiety

Mathematics teachers need to be counselors too ...

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, and
- 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.

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.