A Study Exploring Exceptional Education Pre-service Teachers' Mathematics Anxiety

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Abstract

Fifty-two exceptional education pre-service teachers getting a K-6 endorsement were involved in this study that investigated the changes in levels of mathematics anxiety before and after a mathematics methods course for education majors. The changes were measured with respect to the use of manipulatives and other activities to make mathematics concepts more concrete and meaningful. Data were collected using quantitative and qualitative measures. Pre-service teachers completed a 98-item Likert-type survey. Informal discussions, informal interviews, and questionnaire-guided narrative interviews were conducted with pre-service teachers. Data revealed a statistically significant reduction in mathematics anxiety in pre-service teachers ($p < .001$). Results of the study have implications for teacher education programs concerning the measurement of mathematics anxiety levels among exceptional education pre-service teachers and the determination of specific contexts in which mathematics anxiety can be interpreted and reduced.

Exploring Exceptional Education Pre-service Teachers' Mathematics Anxiety

How *should* a teacher finish this statement? Mathematics is ?..... **"**scary!,"….**"**definitely my worst subject ever!"…something I dread and hate..literally!"….. **"**making me nervous and anxious just thinking about it!" These were just a few of the responses from exceptional education pre-service teachers when asked what mathematics meant to them. Their answers are typical of many individuals in education. It is critical to consider their responses in a field where students who are struggling need assistance from teachers who have to help them overcome an area the teacher themselves might fear.

Why do some teachers struggle with mathematics? Mathematics has its own language with sets of rules to be followed and formulas that need to be memorized. It is full of abstract concepts and problems waiting to be solved. As evidenced by the above responses, sometimes the mere mention of the word "mathematics" can cause anxiety in some individuals. Known as mathematics anxiety, this learned behavior, experienced by many can escalate and become worse over time if not addressed (Gresham, 2009). For individuals with mathematics anxiety, learning mathematics is often difficult. Mathematics anxiety generates a negative attitude toward the subject and is linked to

poor academic performance and feelings of frustration (Battista, 1990; Gresham, 2009; 2007; Hembree, 1990; Tobias, 1998; Vinson, 2001, Zettle & Raines, 2002).

Mathematics anxiety is a well researched topic and has become an emerging area of research and concern in our society (Gresham, 2009). Learning disabilities in mathematics and how mathematics anxiety may contribute to learning problems has generated very little research. Although reading disabilities are more commonly an area of concern, learning disabilities in mathematics are becoming more and more of a focus by educators (Benedictis, Jaffe, & Segal, 2005). Individuals who experience significant problems learning and applying mathematics manifest their mathematical learning problems in a variety of ways. Research indicates that there are numerous reasons individuals experience difficulty learning mathematics and educators are beginning to pay more attention that some students do have difficulty learning mathematics skills and concepts taught in today's classrooms (Furner & Berman, 2003; Furner & Duffy, 2002; Gresham, 2008; Mercer, Jordan & Miller, 1996; Mercer & Mercer, 1998). Identifying and addressing mathematics difficulties in the early grades can potentially prevent more serious problems in later grades (Vinson, 2001). This prevention of problems relies heavily on the quality of mathematics instruction and meeting the needs of *all* learners in the classroom. It also directly depends on the preparation of pre-service teachers (Battista, 1990; Gresham, 2009; 2008; 2007; Swars, Daane, and Giesen, 2006; Vinson, 2001). Without sufficient knowledge of mathematics, mathematics anxiety, and mathematics learning disabilities, it is unlikely that pre-service teachers will be able to deliver sound mathematics instruction to their students (Benedictis, Jaffe, & Segal, 2005). Teaching mathematics to students with special needs is an area of increasing professional consideration and one in which there is somewhat limited empirical investigation. Therefore, this study will take a closer look at mathematics anxiety, learning disabilities in mathematics, and the exceptional education pre-service teachers' experience in an elementary mathematics classroom.

Mathematics Anxiety Identified

Mathematics anxiety has been defined as an irrational dread of mathematics that interferes with manipulating numbers and solving mathematics problems within a variety of everyday life and academic situations (Battista, 1990; Gresham, 2009; Tobias, 1998). It is the helplessness and panic one experiences when asked to perform mathematical tasks (Bursal & Paznokas, 2006). Described as the "I can't syndrome," mathematics anxiety can be caused from a single humiliating mathematics experience or through a lack of applied understanding and application of mathematical concepts (Furner & Berman, 2005). It often leads to avoidance of the subject and creates a negative attitude toward mathematics (Burns, 1998). Specific to mathematics instruction and mathematics related activities, mathematics anxiety inhibits mathematics performance and learning (Gresham, 2004; Vinson, 2002). Mathematics anxiety has been identified as a characteristic in individuals who have learning problems and is considered to be both emotional and cognitive in nature. It is a frequently encountered condition in all levels of education. Identifying and understanding mathematics anxiety as well as finding ways to avoid or reduce it are crucial for successful mathematical learning.

Research on Mathematics Anxiety and Mathematics Learning Disabilities

Research regarding mathematics anxiety and learning disabilities in mathematics is ongoing. Extensive research on mathematics anxiety has tried to determine why so many people in the United States demonstrate a fear or even antipathy toward mathematics (Bursal & Paznokas, 2006; Clute, 1984; Emenaker, 1996; Gresham, 2009; 2008; 2007; & 2004; Harper & Daane, 1998; Hembree, 1990; Jackson & Leffingwell, 1999; Tobias, 1998; Vinson, 2001). Much has been written regarding the causes of mathematics anxiety such as assigning the same work to everyone, teaching the textbook problem by problem, and insisting on only one way to complete a problem. Individuals learn most about a particular subject when they learn how to "obtain knowledge for oneself for use of one's own mind" (Bruner, 1961, p. 22 quoted in Dricsoll, 1994). Effective approaches such as using problem based learning, concrete experiences, incorporating real-life simulations, and implementing hands-on strategies have been known to reduce mathematics anxiety (Driscoll, 1994, Vinson, 2001, Zettle & Raines, 2002). The very nature of instruction itself seems to be a powerful source in shaping latter attitudes, expectations, and conceptions of learning in mathematics.

Research on understanding more completely what a mathematics disability means and what we can do about it in school has lagged behind similar work being done in the area of reading disabilities (Geary, 2000; 2004). It is not fully understood how a mathematics disability affects an individual's ability to learn mathematics in all of the different areas because of the limited research base. To date, the majority of research has focused mostly on the skills associated with mathematics calculations including number, counting, arithmetic combinations or basic facts, and problem solving. Much less is known about development and difficulties in areas such as algebra, geometry, measurement, and data analysis and probability (Geary, 2004; Rivera, 1997; Robinson, Menchetti, & Torgesen, 2002). What is known is that individuals who exhibit problems learning mathematics skills and concepts that persist across their academic years usually carry these difficulties into their adulthood and profession (Robinson, Menchetti, & Torgesen, 2002). Researchers and educators are focusing efforts on better understanding the issues these individuals face as they encounter the mathematics curriculum across the grade levels (Geary, 2000; 2003; 2004; Bryant & Rivera, 1997; Robinson, Menchetti, & Torgesen, 2002).

Pre-service Teachers and Instruction

Many pre-service teachers do not feel confident in their ability to do mathematics. Fortunately, attention is now being directed toward the mathematics curriculum and in helping those who struggle learning basic mathematics skills, mastering more advance mathematics, and solving mathematics problems (Bursal & Paznokas, 2006). Although the National Council of Teachers of Mathematics (NCTM) strongly encourages teaching mathematical understanding and reasoning, the reality for pre-service teachers with mathematical learning problems is that they spend most of their mathematical time learning and practicing computation procedures and have little confidence in their ability to learn more advanced mathematical skills (Zettle & Raines, 2002).

Being confident and knowledgeable in the subject matter is critical in shaping one's attitude toward mathematics including the attitudes of pre-service teachers (Jackson & Leffingwell, 1999). Studies have indicated that mathematics anxiety has implications for teacher practices in mathematics (Bursal & Paznokas, 2006; Bush, 1981; Gresham, 2004;

Vinson, 2001; Zettle & Raines, 2002). Teachers with high levels of mathematics anxiety use more traditional teaching methods, such as lecture. They concentrate more on teaching basic skills rather than concepts and devote more time to seatwork and whole class instruction. Therefore, it is very important for pre-service teachers to have an understanding of the mathematics curriculum and knowledge of effective non-traditional approaches to teach mathematics effectively. Utilizing non-traditional approaches in the mathematics classroom such as using manipulatives to bridge from concrete to abstract, implementing a variety of teaching techniques such as playing games, problem solving strategies, small-group and individualized instruction, and addressing individuals attitudes towards mathematics can help lessen mathematics anxiety (Gresham, 2009; 2007; Taylor & Brooks, 1986; Vinson, 2001). Further, incorporating these instructional techniques and those suggested by NCTM (2000) can also help with individuals who have learning disabilities in mathematics. One commonality has been found among mathematics programs reporting a reduction in mathematics anxiety (Taylor & Brooks; Vinson, 2001) and success in working with individuals with mathematical learning disabilities (Geary, 2000; 2004; Robinson, Menchetti, & Torgesen, 2002). This commonality indicated that teachers introduced the material very slowly, the instructor assumed no prior mathematical knowledge, and individuals were encouraged to discuss their own thought processes in learning (Wood, 1988). The most successful instructional mathematical programs were those featuring teachers who attempted to change the way mathematics was perceived and learned as well as through changes in instructional strategies (Bursal & Paznokas, 2006; Teague & Austin-Martin, 1981, Wood, 1988).

Research also indicated that individuals with learning disabilities are increasingly receiving most of their mathematics instruction in general education classrooms especially with No Child Left Behind (NCLB) and Individuals With Disabilities Education Act (IDEA) indicating that individuals with disabilities must be a part of local and state assessments. Studies show that these individuals benefit from general education mathematics instruction if it is adapted and modified to meet the individual needs of the learner (Geary, 2004; Rivera, 1997). To ensure effective instruction, adaptations and modifications for instruction are necessary in the areas of lesson planning, teaching techniques, formatting content, adapting media for instruction, and adapting evaluation. Regardless of where those with learning disabilities are taught mathematics, individualization is going to be needed to adequately address the impact of the specific mathematics disability that emerges from each individual's unique learning characteristics.

Pre-service teachers have limited teaching experiences and therefore have lessened opportunities in identifying mathematics learning disabilities and mathematics anxiety in the students they directly teach. Research has shown that pre-service teachers have disproportionately high levels of mathematics anxiety (Battista, 1990; Burns, 1998; Bursal & Paznokas, 2006; Gresham, 2009 & 2004; Kelly & Tomhave, 1985; Singh, Granville, & Dika, 2002; Sovchik, Meconi, & Steiner, 1981; Vinson, 2001). Obviously, limited teaching experiences, coupled with high levels of mathematics anxiety in pre-service teachers is a concern. As a result, educators believe that pre-service teachers must be adequately prepared in mathematics. This preparation should be done through mathematics methods courses offered by teacher education programs. This study was

conducted with exceptional education pre-service teachers in a mathematics methods course to add to the body of research and knowledge.

The Study

This study investigated the levels of mathematics anxiety in pre-service teachers who were majoring in exceptional education. It also examined whether their mathematics anxiety can be reduced after participation in a mathematics methods course that also included a 12-week teaching experience practicum. The research was conducted during 5 different sections of the same methods course during the fall and spring semesters. The subjects were fifty-two exceptional education pre-service teachers from a large southeastern university who were enrolled in a mathematics methods course focusing on methods for teaching elementary mathematics. Exceptional education pre-service teachers chose to take this course as an elective and were combined with other pre-service teachers seeking a K-6 endorsement in elementary education. The participants were overwhelmingly female (50 of 52); therefore no attempt was made to differentiate results by gender. The subjects were working toward a K-6 endorsement in exceptional education from the state. All subjects had completed at least two university mathematics courses. Pre-service teachers were informed both verbally and in writing that their participation in the study was completely voluntary and would not influence their grade in the course.

The Mathematics Anxiety Rating Scale (MARS) was used as the quantitative instrument for this study (Richardson and Suinn, 1972). It is a 98-item, self-rating Likert-type scale that may be administered either individually or to groups. Each item on the scale represents a situation which may arouse mathematics anxiety by indicating "not at all," a little," "a fair amount," "much," or "very much." The statements describe everyday life and academic situations requiring mathematical thought or tasks and are rated as to the degree of anxiety that respondents perceived they would experience in the given situations. Richardson and Suinn (1972) reported a test-retest reliability coefficient of .97. The test-retest reliability for the instrument has been shown to range from .78 to .85 and internal consistency has been reported as .97. Scores range from 98 to 490, with the higher scores indicating higher levels of mathematics anxiety.

Pre-service teachers were given the MARS pretest on the first day of class for the semester. During the mathematics methods course, pre-service teachers participated in a variety of activities that included discussion sessions, journal writing experiences, teacher directed large and small group activities, literature based mathematical activities, group presentations, hands-on approaches to teaching mathematic content, and a 12-week field experience practicum in a K-6 classroom. Following the MARS pretest, one entire class period was used to explain the required format for the lesson plan used in the field practicum experience. The format required national, state, and local standards, lesson objectives, lesson planning procedures, ESOL and special needs modifications, and assessment procedures. During the field experience practicum, each pre-service teacher taught a minimum of six (6) lessons. Pre-service teachers were required to teach a new mathematics concept for each lesson, use and implement concrete manipulatives, and integrate literature into the mathematics curriculum. Pre-service teachers had to describe in detail in the lesson plan how the material would be modified and/or enhanced to meet *all* students' needs and how assessment of the lesson would occur. They were required to implement the modifications during the teaching process and assess their students after

each teaching experience. The field experience was supervised by both a university faculty member and the pre-service pupil's full-time teacher. Pre-service teachers were required to keep journal logs of their thoughts and processes during the 12-week teaching experience and duration of the semester course. During the last week of the semester, pre-service teachers were given the MARS as a posttest.

The qualitative methods of the study included informal observations of exceptional education pre-service teachers during the methods course taught for the semester, questionnaire-guided narrative interviews, informal discussions, and informal interviews that were either initiated by the pre-service teacher during or after class or by the professor (the researcher in this study). The interviews were usually in response to questions by pre-service teachers regarding their own personal concerns, experiences, background, assignments, and mathematical teaching practices (See Appendix A for specific interview questions). These questions were used to gather information on exceptional education pre-service teachers' perceptions of their own skills and abilities to teaching mathematics effectively as well as to how their mathematics anxiety may have affected these perceptions. Additional questions were asked only as follow-up or clarification to their responses. Field notes and audio recordings of interviews and discussions were used and analyzed and decoded for emerging themes.

Results and Discussion

The pretest MARS score was subtracted from the posttest MARS score for each to reveal to difference score (See Table 1). A positive difference score meant that the pre-service teacher's mathematics anxiety actually increased during the semester. A negative score meant that the pre-service teacher's mathematics anxiety decreased by that much. Table 1 shows the raw score means by group (semester).

Table 1: Mathematics Anxiety Raw Score Means

Semester & Section	Pretest	Posttest	Gain	Students Per Section
Fall -Section 1	206.43	177.23	-29.20	10
Fall -Section 2	198.22	166.06	-32.16	13
Spring -Section 1	199.12	155.33	-43.79	9
Spring -Section 2	201.00	170.82	-30.28	11
Spring -Section 3	209.11	169.81	-39.30	9
All Groups	**202.76**	**167.85**	**-34.93**	**52**

Table 2 provides the t-test comparisons of pretest and posttest raw scores by sections in each semester. After comparing group means for the pretest and posttest scores, it was found that overall pre-service teachers' mathematics anxiety was reduced. In addition, pretest and posttest raw score differences were highly significant.

Table 2: T-test Comparisons of Pretest and Posttest Raw Scores by Semester

Semester	Variables	t	df	p
Fall -Section 1	Pretest-Posttest	16.22	9	.0000
Fall -Section 2	Pretest-Posttest	21.39	12	.0000
Spring -Section 1	Pretest-Posttest	29.11	8	.0000
Spring -Section 2	Pretest-Posttest	24.37	10	.0000
Spring -Section 3	Pretest-Posttest	22.98	8	.0001

Informal interviews, questionnaire-guided narrative interviews, discussions, and journal logs indicated the emergence of several themes. Pre-service teachers were specifically asked what they felt contributed to their decrease in mathematics anxiety. Forty-seven of them attributed their mathematics anxiety reduction to a combination of strategies that occurred during the semester. These included: (a) having a better understanding of the methodology and strategies that were introduced throughout the semester to help students who have mathematics anxiety and to aid those with learning disabilities, (b) using manipulatives as aids in teaching the lesson effectively which included base-ten blocks, Cuisenaire rods, fraction circles and towers, cubes, two colored counters, attribute blocks, color tiles, geoboards, tangrams, money, pattern blocks, decimal squares, 10 frames, geometric solids, and balance scales (c) having group discussions about their thoughts, concerns, and overall journey of the teaching process during class, and (d) writing about their thoughts during the entire semester. Seven pre-service teachers specifically indicated that the enthusiasm of the professor in teaching the subject content and inviting atmosphere of the course also contributed to their decrease in mathematics anxiety. Many pre-service teachers commented that they finally "understood concepts such as algebra, probability and statistics, fractions, decimals, and percents when the topics were presented in a concrete and practical format". Others commented that mathematics was now less "intimidating" and "scary" to them, noting that perceptions of their abilities to understand mathematics concepts were now enhanced. The most unanimous and interesting comment was that they felt as though their mathematics anxiety could have been prevented in elementary school, if they had received instruction of mathematics concepts through the use of concrete manipulatives.

Four pre-service teachers had an increase in their mathematics anxiety. They expressed concern and much difficulty with modifying and adapting the lesson, trying to learn mathematics while incorporating manipulatives into the lesson planning, and in knowing which strategies to use according to student needs. They also found it intimidating to integrate mathematics and literature into their lesson planning. Even though they were given numerous book lists and websites with literature, expressions of hardship were discussed in finding the appropriate reading material for their grade level.

One student had a significant increase in her mathematics anxiety. After interviewing this student, she indicated that teaching and having to work with *all* types of students in the classroom was very stressful and not what she had expected. She implied that being

unfamiliar and intimidated by manipulatives and having to learn how to use them for classroom instruction was very hard. She indicated that having to modify lessons for different students was very time consuming and a task she certainly did not enjoy or want to do on a daily basis and was questioning her decision to be an exceptional education teacher. She expressed a great desire to discontinue the exceptional education program and did indeed withdraw from the university at the semester's end.

Many strategies to reduce mathematics anxiety in pre-service teachers were provided and implemented throughout the study. As a result, Appendix B includes suggestions (Hackworth, 1992; NCTM, 2000) that can be used for preventing or reducing mathematics anxiety in pre-service teachers. These recommendations also closely parallel recommended suggestions for individuals with learning disabilities. Employing best practices for teaching mathematics helps lessen mathematics anxiety (Zemelman, Daniels, & Hyde, 1998). Pre-service teachers were encouraged to use best practices for teaching mathematics during their practicum in the classroom (See Appendix C).

Summary

NCTM (2000) indicated that excellence in mathematics education requires equity—high expectations and strong support for *all* individuals. The principles acknowledge that individuals need high-quality instruction and materials in learning environments that support them. Individuals with learning disabilities in mathematics may need special accommodations to meet high mathematics expectations (Furner & Duffy, 2002). Pre-service teachers with mathematics anxiety may need the same or different approaches, to prevent or reduce mathematics anxiety to assist them in becoming confident mathematical thinkers. Teachers are the single most important influence on the quality of an individuals' mathematical learning. They take the lead in organizing instruction, choosing what mathematics content should be emphasized, and in shaping other's attitudes and dispositions to learn mathematics (Gresham, 2009; Joyner & Reys, 2000).

The concrete experiences helped the exceptional education pre-service teachers have a better understanding of the procedural purposes and mathematical concepts. As per the interviews, the use of manipulatives aided the pre-service teachers in learning how to teach mathematics. Exceptional elementary teachers must learn how to incorporate a variety of methods to meet each student's unique needs. Accommodations and modifications such as modeling, providing concrete representations from pictorial to abstract, using technology, providing "authentic" experiences for construction and reinforcement of concepts, developing daily routines, using cooperative learning groups, encouraging students to provide answers in written, verbal, and pictorial format, and using a variety of teaching methods and strategies will be beneficial. Effective teachers possess an amazing array of tools perfectly designed to meet the varying needs of every student.

Teaching that enables *all* individuals to learn mathematics calls for teachers who have the knowledge and skills to meet students' needs, organize sound instruction, and are supported in their efforts to improve their own skills and knowledge. Providing pre-service teachers with non-threatening, risk-free opportunities to learn and practice math skills is greatly encouraged. Celebrating both small and great advances is also important. If teachers learn to provide instruction that is effective for individuals with mathematics anxiety and for those with learning disabilities, we will help students learn mathematics.

Teachers who understand the learning needs of others are more empowered to provide the kind of instruction their own students' need. Knowing why a pre-service teacher is struggling to learn mathematics provides a basis for understanding why particular instructional strategies and approaches are effective. Researchers and teachers must continue to work together to determine which curricula and instructional practices will bring the best results in mathematics achievement. There is no doubt that for some, mathematics is and will remain challenging. However, we want individuals to understand mathematics. As teachers' model problem solving strategies daily, monitor the use of them, and encourage the use of these strategies in a variety of ways, individuals will learn to generalize these strategies into other areas and become independent learners. Educators do have an impact upon their students. Understanding mathematical content and its presentation will help exceptional education teachers teach their students effectively, thus preventing or reducing mathematics anxiety in their future students.

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Appendix A

Interview Questions

1. What do you think when you hear the word mathematics?
2. For me, mathematics is most like….?
3. Do you perform well in mathematics?
4. How confident do you feel when asked to perform mathematics problems?
5. Describe your most memorable teaching moment while teaching mathematics in your internship. Why does this stand out in your mind?
6. How do you feel about mathematics?
7. How confident are you when teaching mathematics?
8. Describe your feelings when teaching mathematics?
9. What do you think contributed to your mathematics anxiety?
10. Do you feel class discussions have helped you this semester? Why or why not?
11. Did this course help you address your mathematics anxiety? How? Why or why not?

Appendix B

- Design positive experiences for mathematical learning and let pre-service teachers know that everyone makes mistakes
- Characterize mathematics as a human endeavor
- Make mathematics relevant and relate it to real-world experiences
- Create a variety of learning environments conducive to student interests
- Accommodate for different learning styles
- Let pre-service teachers have input into their own evaluations and help them learn to evaluate their own learning
- Remove the importance of ego from the classroom
- De-emphasize rote manipulation of formulas and emphasize quality thinking
- Use journaling to discuss and write about math feelings
- Recognize what information needs to be learned
- Encourage students to be an active learner and listener
- Create many problem solving techniques
- Encourage students to develop good study habits
- Create a mathematics community that thrives on conjecturing, inventing, and problem solving to build mathematics confidence.
- Build mathematical confidence using repeated successes
- Help them understand their mathematical fear and encourage them to develop ways to deal with mathematics by using positive messages and relaxation techniques.

Appendix C

- Use class discussion

- Use small and whole group work including cooperative group lessons
- Use concrete manipulatives to make mathematics meaningful
- Use journal writing for thinking and expressing feelings
- Use more than one way to solve problems
- Use calculators, computers, and all technology
- Provide models of assignments and criteria for success
- Make your expectations explicit
- Apply known mathematical concepts to new situations for problem-solving
- Serve as a facilitator of knowledge
- Assess your learning as part of the instruction process.