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Mathematics Anxiety and Pre-Service Teachers

Margaret O'Toole
Xavier University - Cincinnati, otoolem1@xavier.edu

Xavier University

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Advised by: Professor Carla Gerberry

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Abstract

Mathematics anxiety has been a topic of interest since the 1950s. It has been shown that apprehensive elementary mathematics teachers unintentionally transfer anxiety to students in their classroom. In this study we assessed the change in 34 pre-service teacher′s anxiety, self-efficacy and perception of ability during and after a content-specific mathematics course. This study used a mixed method approach for analyze data. The results suggests that anxiety decreased over the semester and perception of ability and self-efficacy increased. The levels of confidence with the material were recorded before and after three exams in the course. The pre-service teacher′s change in levels of confidence following the exams rose from an average of 2.98 to a 4.30 level out of 5. We chose three students from the participants who gave different pictures of their feelings towards mathematics to investigate in detail.

BACKGROUND

In the early 1950s, D.C. Gough (1954) set out to explain why some of her students failed only mathematics courses despite high proficiency in other content areas. After a brief period of research, she used the word "mathemaphobia" to describe anxiety related to mathematics. In 1957, subject specific anxiety was examined by Sarason (1957) for its influence on possible experimental and functional standards. Sarason (1957) and Suinn (1965) have shown that particular types of anxiety have different effects on scholarly performance. Professor Frank C. Richardson and Professor Richard M. Suinn investigated the effects of mathematics anxiety on 397 college students. In 1970, Suinn′s research indicated that mathematics anxiety existed among many individuals who had not previously suffered from any former anxiety. Richardson and Suinn (1972) defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations." These ordinary life and academic situations include basic number manipulation and modeling of real world problems.

In 1951, W.H. Dutton conducted research concerning attitudes of prospective elementary school teachers. These pre-service teachers were questioned during a methods course at a university. Dutton′s research was consistent with a later study conducted by Harper and Daane. Harper and Daane (1998) reported that a lack of understanding and interest in mathematics lead to feelings of insecurity and inferiority. It is suggested that in mathematical anxiety is rooted in teaching (Uusimaki and Nason, 2004; Malinsky, Ross, Pannellis, McJunkin, (2005). University students, who have been identified as math anxious, identified an experience from elementary school that has lead them to be anxious about mathematics. These experiences were described as uncomfortable, embarrassing, and frustrating.

Several definitions of mathematics anxiety have been proposed as the number of math anxiety studies increase. Richardson′s and Suinn′s definition states that math anxiety simply interferes with basic number manipulations. It has been proposed that math anxiety is not just an interference, but "an irrational and impeditive dread of mathematics" (Lazarus, 1974) or the "panic, helplessness, papralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem" (Ashcraft, 2002; Wood, 1988).

Regardless how one defines mathematical anxiety, all definitions relate to some emotional response that disrupts performance. Mathematics anxiety may prevent students from passing fundamental math courses and therefore reduce the desire to further an education regarding a mathematics related career (Ashcraft, 2002).

The major factor that sets mathematics anxiety apart from other scholarly subjects is that math anxious students consistently report a fear of getting an incorrect answer and completing their work using the "correct" algorithm (Harper and Danne, 1998; Cates and Rhymer, 2003). This fear is not specific to one form of arithmetic. Student′s recalled that their elementary teachers relied heavily on drill practice, timed tests, and getting the correct answer when assessing knowledge and growth (Harper and Daane, 1998; Hadfield and Lillibridge, 1991; Sloan, Daane, Giesen, 2002). It is a concern that teachers with a higher level of mathematics anxiety unknowingly pass on their negative feelings to their students (Sloan, Daane, Giesen, 2002).

The Mathematics Anxiety Rating Scale (MARS) was constructed to help measure math anxiety concerning the manipulation of numbers and additional use of mathematical ideas in problem solving. The MARS is a 98-item questionnaire that asks students to reflect on certain situations. The test is composed of situations to assess a person's attitude, confidence, and performance levels relating to mathematics in everyday situations.These situations are diverse and may provoke different levels of anxiety based on scenario. In response to the prompt, numerical values ranging from 1 to 5 correspond to the level of anxiety the scholar would expect to feel in a given situation. A response with a value of 1 means "little to none" and 5 means "very much." The final score is the summation of all answers out of a possible score of 490. The higher the reported score, the more anxious the scholar is said to be concerning mathematics. Richardson and Suinn reported a test-retest reliability coefficient of .97. The MARS is said to serve a diagnostic tool for psychologists. Also, the normative data presented by Suinn and Richardson serves as a tool to assess different treatment approaches to math anxiety (Richardson Suinn, 1972).

Currently, research around mathematics anxiety is directed towards reducing the possibility of a high school teacher transferring his or her mathematical anxiety to students. The number of publications around this topic has dramatically rose in the last decade. In 2005, Ashcraft and Ridley published *Handbook of Mathematical Cognition*. This article aims to review the knowledge available relating to mathematics anxiety. This publication also updates the causes and effects of mathematics anxiety from the perspective of neuroscience (Suarez-Pellicion, Nunez-Pena, Colome, 2015).

Educational programs, such as common core, aim to address negative trends in the American educational system. In 2009, common core was developed to set clear expectations for all students who plan on entering college or the workforce following high school. Part of the developmental process was defining clear standards for what every child should know prior to graduating high school. These standards are broken down by grade level and content area. Common core stresses the use of differentiated instruction to meet the needs of all students. This means that content is presented in multiple ways to allow students to chose different avenues to learn.

The following study consists of 34 pre-service teachers in two mathematics classes for early and middle childhood educators respectively. Students make use of journals, manipulatives, and group discussions among other engaging activities to explore mathematics. The purpose of this study is to assess how a content course specific to pre-service teachers affects mathematics anxiety and overall understanding of mathematics.

METHODS

This study consists of 34 pre-service teachers. All participants were enrolled in the courses math 201 or 211; math for early or middle childhood educators. This study was conducted at a private mid-sized university in an urban area. The pre-service teachers volunteered to participate in three interviews throughout the semester at the university. Students were informed verbally that their participation in these interviews was voluntary. Their responses would not affect their grade in the course. Students were given the choice of extra credit or a gift card for participating in the study. Prior to the interviews, students were not informed that the purpose of the interviews was to collect data concerning mathematics anxiety and confidence levels towards mathematical content.

The interviews were conducted on three separate occasions throughout the fall semester of 2015. All interviews immediately followed three exams throughout the semester. Each interview consisted of a series of questions. The first four questions related to the students′ confidence before and after the exam. The first question prompted students to give three words describing how they felt before the exam. Next, students were asked to give three words describing how they felt immediately after the exam. Questions three and four asked students to rate their confidence, relating to the material, before and after the exam on a scale of one to five. A score of one correlated to a low level of confidence while a score of five correlated to a high confidence level. These four questions were addressed after every test. The next set of questions varied after each exam. These questions related to the students′ general feelings towards mathematics. Participants answered between 6-8 questions for each interview.

The first test given during the semester related to Venn diagrams. Question five and six during the first set of interviews asked students to elaborated about their nightly routine before a test. Students were asked to comment on the amount of sleep and how much they studied the day before the test. The final question encouraged students to elaborate on how much they worried about mathematics in comparison to other classes. Students were free to respond how they deemed necessary. Word choice and inflection in tone were noted for all questions.

The second test related to number theory. During the second round of interviews, students answered a total of six questions. Question five encouraged students to comment on the number of math classes he or she needed to graduate. Students were prompted to respond with a number 1-5. A response of 1 correlated with unfavorable feelings towards the number of classes. A response of 5 correlated with positive feelings towards the number of math classes required. Question six pressed the student to reflect on his or her ability at this point in time to use an alternate algorithm to solve an unknown math problem if it was presented to them at this moment. The student was asked to first respond by stating if he or she would be able to complete the task. Also the student was asked to comment on the value of the task. Word choice and tone were noted during the interview.

The third round of interviews consisted of six questions. Question five asked the student to comment on how much he or she worried about school in general. The students were free to respond how he or she deemed fit. Question six asked the student to reflect on the scenario if an instructor were to ask verbal questions to measure how much he or she knew in mathematics. The student was asked to comment on how he or she would feel in the situation.

After all interviews were conducted, Microsoft Excel was used to organize the data. This document was titled "All students." A new data tab was produced for each set of interviews. Each data tab corresponded to a different class. In that data tab, the columns were organized by a brief description of the interview question. The rows were specific to individual students and the answers given during the interview. After all data was uploaded to the document, students were alphabetized and given a pseudonym to protect anonymity. The pseudonym was created based on the course number, section, and semester that the students were enrolled in when interviewed. Students who interviewed three times were given an alias in bold font. The document containing the student aliases was saved separately from the collection of data. Then each student"s name was replaced the corresponding alias.

Next, a new document was created for students who interviewed three times. It was organized in the same manner as the "All Students" document. Each data tab corresponded to a separate interview. The columns were titled with a brief description of the interview question. Rows were organized by individual student IDs and responses to interview questions. From this document, three students who painted an interesting picture were chosen for further analysis. This document was titled "Interviewed three times."

Questions one and two were revisited to group similar words from the students′ responses. An iterative process was used to help create the grouping. The course and interview administrators created two seperate groupings of words. Next, the two administrators collaborated on editing the groupings. Once the edits were agreed upon, each group was then coded with a word that best summarized the general impression of the words in the group.

After the codes were created, questions one and two were revisited in the "All students" and "Interviewed three times" documents. Two new excel document were created and titled "All students new codes" and Interviewed three times new codes." This document organized students responses using the simplified codes created by the course and interview supervisors.

Results

Table 0.1 displays all codes and the number of times the codes were used in response to question one from the three interviews. After comparing the responses to question one from all three interviews it was observed that anxious was the most used code from interview one. The most used word from the second set of interviews was also anxious. Finally, confident was the most used code from the third interview.

Table 0.2 shows the responses to question two from all interviews. This table displays all codes and the number of times the codes were used when responding to the prompt. After comparing the responses to question two from all three interviews it was observed that anxious was the most used code from interview one. The most used word from the second set of interviews was confident. Finally, confident and comfortable were the most used codes from the third interview.

The means of the numerical responses from question three and four were calculated. Table 0.3 displays the calculated means, standard deviation, and number of number of responses from question three. Student's confidence before the three exams increases by 0.6699. Table 0.4 displays the responses for question four. Students' confidence increased from 2.9814 to 4.3065 from the first test to the third test. The change in confidence from before the first test to after the third test increased by 1.186.

Next, three students were chosen from the participants. The first student that was chosen was student, 33-211-F15. This student will be referred to as Jack. Jack's responses to question one were consistently coded with anxious, prepared, and confident for all three interviews. However, his responses to question two were coded with hurried, indifferent, and undecided. After the first test, Jack responded with a confidence level of 2. When asked to elaborate on his response Jack said "I have never seen math without numbers." Also, Jack reported that he worried more about mathematics than any other subject.

The second student that was chosen was student, 10-2011-F15. This student will be referred to as Sarah. The codes that Sarah reported before the first test were confident and comfortable. After the first test, Sara's responses were coded as anxious and underprepared. In response to the the question "How much do you worry about math verses other subjects," Sarah responded

Code	Interview 1	Interview 2	Interview 3
	n=27	n=34	n=31
Anxious	17	17	15
Comfortable	5	6	10
Confident	9	14	17
Hurried	1	2	3
Indifferent	5	4	4
Prepared	6	12	10
Tired	2	0	0
Undecided	2	4	3
Underprepared	4	3	3

Table 0.1: Shows codes and number of responses to question one.

Code	Interview 1	Interview 2	Interview 3
	n=27	n=34	n=31
Anxious	15	9	5
Comfortable	9	9	21
Confident	12	17	17
Hurried	6	6	0
Indifferent	2	4	3
Prepared	1	2	6
Tired	1	1	1
Undecided	7	4	4
Underprepared	7	2	1

Table 0.2: Shows code and number of responses to question two

by saying "Math is the worst! It causes the most stress." When the third round of interviews occurred, Sarah reported a confidence level of 4 for questions three and four.

	Interview 1 n=27	Interview 2 n=34	Interview 3 n=31
Average	3.1204	3.7167	3.7903
Standard Deviation	0.9741	0.8060	0.7277
Variance	0.9489	0.6497	0.5295

Table 0.3: Shows the responses from question three.

	Interview 1 n=27	Interview 2 n=34	Interview 3 n=31
Average	2.9814	3.4433	4.3064
Standard Deviation	1.1806	1.0682	0.5579
Variance	1.3939	0.1411	0.3113

Table 0.4: Shows the responses from question four.

The third student that was further examined was 28-211-F15. This student will be referred to as Mary. For the first and second interviews, Mary's responses to question one were consistently coded as prepared and confident. For question two, Mary's responses were consistently coded as hurried and anxious. The third round of interviews was the only time that Mary reported an increase in confidence from before to after the test. In the third interview Mary was given the situation that someone was going to ask her about how much she knew in mathematics. Mary responded by saying that she would panic and that her anxiety was increasing just from thinking about the situation.

DISCUSSION

The overall trend in the qualitative and quantitative data suggests that a content course specific for pre-service teachers decreases mathematics anxiety. Also, the positive change in levels of confidence with the material suggests that the course facilitates an increase in understanding of mathematics and self-efficacy. The data falls in line with the findings of several studies. It has been found that a high level of anxiety towards mathematics corresponds to a lower level of knowledge concerning the subject (Meece, 1981; Wigfield and Meece, 1988 and Harper, Daane, 1998). In 1976, Fennema and Sherman found that math anxiety and mathematical ability concepts were negative and highly correlated (r=-.89) after sampling a group of high school students. Jack, Sara, and Mary all reported a decrease in thier levels of confidence after the first test. Mary and Sarah directly stated that math induces feelings of emotional distress. While Jack′s response suggests his exposure to mathematics has been very limited.

The structure of the content course falls in line with research from Harper and Daane. Harper and Daane (1998) reported that students with high mathematics anxiety originated from ridged instructional practices in the classroom. From the study of Harper and Daane (1998), college level students reported feelings from elementary school of overwhelming pressure to quickly find the correct answer to a problem in the "right" way. If students could not do so, they recalled feeling embarrassed or inferiority in the classroom. Research suggests that teachers who are less confident with the material spend 50 percent less time in the classroom exploring content topics and resort to memorizing algorithms (Schmidt and Buchmann, 1983; Karp, 1991).

The teacher's beliefs about mathematics will influence the students. If Jack, Sara and Mary were to enter an elementary classroom now, research supports the hypothesis that their anxieties about mathematics might be transferred to their students. Uusimaki and Nason (2004) reported that teachers with high efficacy and content knowledge have lower levels of mathematics anxiety. Therefore, classroom activities directly reflect a teacher′s beliefs about mathematics. The results of previous studies support the goals of the common core to reduce content specific anxiety. To reduce levels of mathematics anxiety students should make use of journals, manipulatives, and group discussions among other engaging activities to explore mathematics. This the structure of the math 201 and 211 courses in this study. Students are encouraged to take an interactive approach when studying mathematics.

The causes of mathematical anxiety is cyclic.The ultimate goal of understand mathematics anxiety is to break the transferring cycle from teacher to student. Bursal and Murat (2006) report that math teachers with a low level of anxiety are more confident to teach elementary mathematics than someone with a higher level of anxiety. Pre-service teachers of all levels should be made aware of their own beliefs about mathematics before entering the classroom. This will help facilitate a stronger interest in mathematics for the future generations.

REFERENCES

Ashcraft, Mark. (2002) Math Anxiety Personal Educational and Cognitive Consequences. *American Psychological Society* 181-185.

Bursal, Murat and Lynda Paznokas, Lynda. (2006) Mathematics Anxiety and Preservice Elementary Teachers' Confidence to Teach Mathematics and Science. *School Science Mathematics* Vol. 106, Issue 4, 173-180.

Bush, L. (1980). Encouraging girls in math. *Multivariate Behavioral Research* Vol. 1 (1980) 245-276.

Cates, Gary and Rhymer, Katrina. (2003) Examining the relationship between Mathematics Anxiety and Mathematics Preformance. *Journal of Behavioral Education* Volume12, Issue 1, 23-34.

Gough, D.C. (1954). Mathemaphobia: Causes and treatements. *Clearing House* Vol. 28, 290-294.

Fennema, E. and Sherman, J.. (1976). Fennema-Sherman mathematics attitudes scales: Instuments designed to measure attitudes toward the learning of mathematics by females and males. *JSAS Catalogue of Selected Documents in Psychology* Vol. 6, 31-32.

Harper, Norma W. and Daane, C.J.. (1998). Causes and Reduction of Math Anxiety in Preservice Elementary Teachers. *Action in Teacher Education* Vol. 19, Issue 4. 29-38.

Hunt, G.E.. (1985). Math Anxiety-where do we go from here. *Focus on Leranin Problems in Mathematics* Volume 7, 29-24.

Karp, K.S.. (1991). Elementary school teachers' attitudes towards mathematics: Rhe impact on student's autonomous learning skills. *School Science and Mathematics* Vol. 91, 265-270.

Lazarus, M. (1974). Mathophobia: Some personal speculations. *National Elementary Principal* Vol. 53, 16-22.

Malinsky, Marci and Ross, Ann and Pannells, Tammy and McJunkin, Mark. (2006). Math Anxiety in Pre-service Elementary School Teachers. emScience Mathematics Vol. 106, Issue 4, 274-286.

Meece, J.. (1981) Individual differences in the affective reactions of he middle and high school students to mathematics: A social cognitive perspective. *University of Michigan*

Richardson, Frank and Suinn, Richard. (1965). Anxiety and Intellectual Performance: A Partial Failure to Replicate. *Journal of Consulting Psychology* Vol. 29, 81-82.

Richardson, Frank and Suinn, Richard. (1972). The Mathematics Anxiety Rating Scale. *Journal of Counseling Psychology* Vol. 19, Issue 6, 551-554.

Sarason, I. (1957). Test Anxiety, general anxiety and intellectual performance. *Journal of Consulting Psychology* Vol. 21, 485-490.

Schmidt, W. H., and M. Buchmann. (1983) Six teacher's beliefs and attitudes and their curricular time allocations. *The Elementary School Journal* Vol. 84, 162-172.

Sloan, Tina and Daane, C.J. and Giesen, Judy. (2002). Mathematics Anxiety and Learning Styles: What is the Relationship in Elementary Preservice Teachers? *School Science Mathematics* Vol. 102, Issue 2, 84-86.

Suarez-Pellicion, M. and Nunez-Pena, M.I. and Colome A.. (2015) Math anxiety: A review of its cognitive consequences, psychophysiological correlates, and brain bases. *Psychonomic Society* 1-20.

Trautwein, Ulrich and Ludtke, Oliver and Koller, Olaf and Baumert, Jurgen. (2006). Self-Esteem, Academic Self-Concept, and the Achievement: How Learning Environment Moderates the Dynamics of Self-Concept. em Journal of Personal and Social Psychology Vol. 90, Issue 2, 334-349.

Uusimaki, Liisa and Nason, Rod. (2004) Causes underlying per-service teacher's negative beliefs and anxieties about mathematics.*International Group for the Psychology of Mathematics Education* Vol. 4, 369-376.

Wigfield, Allan and Meece, Judith. (1998). Math Anxiety in Elementary and Secondary School Students. *Journal of Educational Psychology* 210-216.

Wood, Eric. (1988). Math Anxiety and Elementary Teachers: What des Research Tell Us. *For the* *learning of mathematics* Vol. 8, 8-13.

Zaslavsky, C. (1994). Fear of Math: How to get over it and get on with your life. *Rutgers University Press*