Mathematics Anxiety of Preservice Elementary Teachers After Completing a Problem Solving Course

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Abstract: Five preservice elementary teachers, who had recently completed a mathematics content course in problem solving and number sense, participated in individual interviews to determine their views about mathematics and their mathematics anxiety. All participants stated that their feelings about mathematics changed in a positive way with consistent references made to "the teacher." University instructors of preservice teachers should be made aware of what can be done to transform preservice elementary teachers who simply tolerate mathematics into inservice elementary teachers who successfully transfer knowledge of and enthusiasm for mathematics.

If elementary mathematics teachers suffer from mathematics anxiety, what message is sent to their students? Who is responsible for producing elementary teachers free of mathematics anxiety? Could it be that the university mathematics instructors of these elementary teachers have some responsibility? In an effort to determine what effects university instructors have, five preservice elementary teachers were interviewed. The intent of this qualitative study was to explore what preservice teachers thought changed their attitudes in a positive manner. The sample size may be considered small, but as the interviews continued, a pattern of similar thought as to what changed the preservice teachers' attitudes became apparent. These results do provide a foundation for more investigation of these questions.

CONCEPTUAL FRAMEWORK

In *Overcoming Math Anxiety*, Tobias (1978) defined mathematics anxiety as a tense and anxious feeling which may obstruct one from manipulating numbers and/or solving mathematical problems. Mathematics anxiety has also been defined as "the

panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" and is sometimes referred to as math phobia or panic (Tobias & Weissbrod, 1980, p. 63). Spicer (2004) may have summed it up best by stating that mathematics anxiety is "an emotion that blocks a person's reasoning ability when confronted with a mathematical situation" (p. 1). In a meta-analysis of 151 mathematics anxiety studies involving third grade through post-secondary students, Hembree (1990) concluded that mathematics anxiety appears to be a "learned condition more behavioral than cognitive in nature" (p. 45).

Mathematics anxiety does not have a single cause. There are some general factors that have been linked to causing and increasing mathematics anxiety such as lack of mathematics preparation, distrust of intuition, and the idea that males perform better than females in mathematics (Tobias, 1978). Although student attitude may be another factor leading to mathematics anxiety, the attitudes of teachers and the teaching techniques employed seem to be a primary cause (Haralson, 2001; Greenwood, 1984). Tobias (1978) wrote that bad experiences with math teachers can foster math anxiety and Fiore (1999) stated that "teachers and the teaching of mathematics are known to be the roots of most mathematics anxiety" (p. 403).

Numerous studies indicate that mathematics anxiety can be passed on to students through their teachers (Lazarus, 1974; Fiore, 1999; Wood, 1988). Zopp (1999) conducted a study with adults over 25 years old and found that specific educational episodes were sources of math anxiety. Jackson and Leffingwell (1999) found that seven percent of the participants in their study had only positive experiences in mathematics classes from the kindergarten level through the university level. The other 93% of the

participants reported negative experiences which generally occurred at certain times – grades 3 and 4 of elementary school, grades 9 through 11 of high school, and the freshman year of college. At each of these levels, some participants indicated that their math anxiety was associated with insensitive and uncaring teachers.

Math-anxious adults include teachers, especially elementary teachers (Williams, 1988). A disproportionate number of elementary teachers experience substantial levels of mathematics anxiety (Buhlman & Young, 1982; Levine, 1996). Chavez and Widmer (1982) found that elementary teachers felt their own performances were acceptable in elementary school, but about half of the teachers interviewed had problems at the secondary and university levels. Sources of the problems included "math content, inadequate, impatient, or sarcastic teachers, low grades ('the only D in my life!'), and parents' impatience with lack of success in math" (Chavez & Widmer, 1982, p. 387). Yet, despite their negative experiences, overall, the teachers were positive about teaching mathematics and worked diligently to spare their own students from similar "unpleasant experiences with numbers" (Chavez & Widmer, 1982, p. 387).

Reys, Lindquist, Lambdin, and Smith (2007) discussed various effects of mathematics anxiety – misunderstandings, poor performance on math tests, uncertainty, apathy, lack of confidence, dislike of mathematics, low motivation, and classroom behavior problems. The effects can also include avoiding mathematics courses, limiting one's selection of college and career choice, declining mathematics achievement, and feeling guilty or ashamed about mathematics (Armstrong, 1985; Betz, 1978; Brush, 1978; Burton, 1979; Donady & Tobias, 1977; Richardson & Suinn, 1972; Tobias & Weissbrod,

1980). Each of these or a combination can affect a student "with far-reaching consequences" (Newstead, 1998, p. 53).

The implications are clear that it is important for teachers at all levels to consider their effect on increasing or decreasing students' mathematics anxiety. Since the first occurrences of math anxiety can often be traced to elementary school, elementary teachers in particular, should be prepared to provide positive mathematical experiences that do not cause or increase mathematics anxiety. In order to prepare these elementary teachers, instructors of preservice elementary teachers should be aware of what they can do in order to reduce mathematics anxiety in their students. If these preservice teachers enter the teaching ranks with lower levels of mathematics anxiety or no mathematics anxiety, then fewer elementary students will have experiences which may increase or decrease mathematics anxiety.

RESEARCH OBJECTIVE

The primary intent of the study was to determine the effectiveness of a problem solving and number sense mathematics course in addressing issues of mathematics anxiety. In particular,

1) If the students' attitudes about mathematics changed while enrolled in the course, then what did they believe were the causes?

2) How was this course different in a positive or negative way than previous mathematics courses?

METHOD

Participants

Approximately 100 students from a public university of approximately 34,000 students were invited to participate in the study. These 100 students had completed the problem solving and number sense course in fall 2004 or spring 2005.

Students majoring in elementary education at this university are required to take two mathematics courses prior to the problem solving and number sense course. The courses usually are college algebra and a survey course including topics such as logic, probability, and data analysis. The problem solving and number sense course is a *National Council of Teachers of Mathematics Standards*-based course that is designed for, but not limited to, preservice teachers of grades kindergarten through sixth grade. The course emphasizes open-ended problem solving using manipulatives for concept development and understanding. It is specifically designed to provide students a working knowledge of mathematics using concrete teaching materials and models emphasizing the importance of "understanding" before practice. Topics include 1) problem solving strategies; 2) number sense; 3) patterns, sequences, and functions; 4) numeration systems; 5) operations with whole numbers, integers, fractions, decimals, and percent; 6) elementary number theory; and 7) ratio and proportion.

This particular course was chosen because of preliminary results from another study of 87 students from four sections of the same course taught in spring 2005 (Plaisance, 2005). For this one semester, the study showed that the students' mathematics anxiety levels were reduced upon completion of the course. Results from the study showed that 61 out of 87 students scored the same or lower on the Mathematics

Anxiety Rating Scale – Short Version (MARS-SV) on a post-test administered at the end of the semester. The differences in the MARS-SV scores (post-test minus pre-test) were examined using a t-test with alpha level of .05 and a null hypothesis stating there would be no difference in scores from pre-test to post-test. The null hypothesis was rejected with a significance value of .001 indicating overall reduction in mathematics anxiety.

An initial electronic mail (e-mail) was sent to approximately 100 students enrolled in the problem solving and number sense course during fall 2004 and spring 2005. This e-mail invited students to participate in an interview relating to mathematics anxiety. Approximately 20 students responded. These 20 students were sent a follow-up e-mail asking the following questions:

1) On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics anxiety was when you entered the course?
2) On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics was when you completed the course?

Students who reported a decrease in mathematics anxiety of at least two points were then invited to schedule an interview within a three-day period. Six students scheduled interviews and five students were actually interviewed.

Procedure

A semi-structured interview was developed in order to examine the students' perceptions about the problem solving and number sense course and their feelings about their own mathematics anxiety. First, the students were asked six demographic-type questions (see Table 1). Then, the students were asked a set of interview base questions (see Table 2). The first four questions related to the problem solving and number sense

course. The next ten questions related to the students' feelings about mathematics in general and their perceptions of mathematics anxiety. Questions in relation to mathematics anxiety were adapted from a set of interview questions developed by Zbornik (2001).

The primary objective of the interview was to examine the students' perceptions about the course – first to determine if the students' feelings about mathematics had changed during the semester and what were the causes, and second to determine if this particular mathematics content course was different in a positive or negative way than previous mathematics courses and what was different about it.

Table 1
Demographic Questions

1. How old were you when you were enrolled in the problem solving and number sense course?
2. What was your university classification when you were enrolled in the problem solving and number sense course?
3. What is your concentration in elementary education (Grades one through sixth or pre-kindergarten through third grade)?
4. What was your course grade in the problem solving and number sense course?
5. What was your course grade in college algebra?
6. What course did you take as your second mathematics course prior to the problem solving and number sense course and what was your course grade?

Table 2
Base Interview Questions

Interview questions relating to the problem solving and number sense course:
1. On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics anxiety was when you entered the problem solving and number sense course? To what do you attribute your initial level of math anxiety?

2. On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics anxiety was when you completed the problem solving and number sense course? To what do you attribute this level of mathematics anxiety?

3. Do you believe your feelings about mathematics changed during the semester you were enrolled in this course? If so, explain.

4. Was this course different than previous college mathematics courses you have taken? If so, explain including telling whether it has been different in a positive or negative way?

Interview questions relating to investigating mathematics anxiety of students:

1. Do you like math? Why or why not?

2. a) Have you ever liked math? What caused you to like math?

Or

b) Have you ever disliked math? What caused you to dislike math?

3. What do you think is meant by mathematics anxiety?

4. What do you think are some symptoms of math anxiety? (i.e., How do you think a person would respond if he/she has math anxiety?)

5. How do you feel when taking a math test, participating in a math class, solving a math problem or listening to a math lecture?

6. What is going through your mind when you are involved in one of the activities described previously or a combination of these activities?

7. Do you worry about taking a math test? What do you worry about specifically?

8. a) How do you feel about your ability to solve a math problem?

b) How do you solve math problems? Can you explain the basic process you use? Do you use scratch paper to work the problem?

c) Do you usually require a calculator? Are there any types of math problems which you do not think you would use a calculator?

d) Can you analyze/take apart a math problem? If so, explain how you do this?

e) Are you able to solve a math problem in different ways using alternate methods? If so, would you give an example of a problem that you may be able to solve in more than one way?

9. Which parts or types of math do you feel proficient in performing? (For example, addition, subtraction, etc.) If so, explain why.

10. Do you have any further comments about anything we have discussed?

Each student participated in an individual interview in November 2005. The interviews lasted approximately thirty minutes. Each interview was audio taped and then

transcribed for coding purposes. Interview questions were developed to address the students' attitudes about the problem solving and number sense course and their perceptions about mathematics and mathematics anxiety.

Coding Students' Responses

The interviews were transcribed (transcription verbatim for most responses). Not all questions were used in the final analysis, but responses to base interview questions used were accounted for in the coding. This study's coding system was of simple design in that the categories were a natural outgrowth of the students' responses. All interviews were reread to check the accuracy of the coding.

Descriptive narratives in paragraph form were used to summarize the responses to selected questions from the set of interview questions relating to mathematics and mathematics anxiety.

RESULTS

Responses to the demographic-type questions (see Table 1) are presented in Table 3. As indicated earlier, five students were interviewed. All students were female and each is identified by a pseudonym. The fifth column in Table 3 is labeled GCA, which indicates the student's grade in college algebra, the first college mathematics course each completed. The sixth column is labeled GSMC which indicates the grade in the second mathematics course taken. Anne, the first student interviewed, had to repeat college algebra and took trigonometry as the second course. The other four students took the survey course consisting of topics such as logic, probability, and data analysis for the second course. The seventh column is labeled GPS, which indicates the student's grade

in the problem solving and number sense course. Students majoring in elementary education can choose a concentration of pre-kindergarten through third grade (PreK-3) or first through sixth grades (1-6). Table 3 provides a "snapshot" of each person interviewed.

Table 3
Responses to Demographic Questions

Interviewee	Age	Classification	Concentration	* GCA	GSMC	GPS
Anne	26	Sophomore	1-6	F;B	B	A
Bonnie	19	Sophomore	PreK-3	B	B	A
Carolyn	21	Junior	PreK-3	D	B	B
Donna	20	Sophomore	1-6	D	C	B
Emma	19	Sophomore	1-6	C	B	B

* GCA (Grade in College Algebra); GSMC (Grade in second math course taken); GPS (Grade in Problem Solving and Number Sense Course)

After answering the demographic questions, each student was asked the following questions:

1) *On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics anxiety was when you entered the problem solving course? To what do you attribute your initial level of mathematics anxiety?* (Entry Level and Entry Reason)

2) *On a scale of 1 to 5, with 1 being low and 5 being high, what do you think your level of mathematics anxiety was when you completed the problem solving course? To what do you attribute this level of math anxiety?* (Exit Level and Exit Reason)

Responses to these two questions are found in Table 4.

Table 4
Responses to Questions Asking for Self-Reported Mathematics Anxiety and Reasons

Interviewee	Entry Level	Entry Reason	Exit Level	Exit Reason
Anne	5	No math in years Idea of teaching math	1 or 2	Being refreshed Different solving methods
Bonnie	4	Poor teachers Inadequate background Lack of confidence	1	Way teacher taught Use of manipulatives Different solving methods
Carolyn	4	Lack of understanding	2	Greater math confidence
Donna	5	Never did well in math Title of course scared her	1	Way teacher taught Use of manipulatives
Emma	4	Poor teachers Self-reported test anxiety	2	Way teacher taught Different solving methods

The most common reason given for entry level of mathematics anxiety was poor teachers and one of the most common reasons for exit level was the way the teacher taught the material. The other most common reason for the exit level was the use of different solving methods. Note that the most frequently mentioned factor among entry level and exit level combined involved the teacher.

Each student was then asked the following question: *Do you believe your feelings about math changed during the semester you were enrolled in this problem solving course? If so, explain.* All students responded "yes" to the first part of the question. Results of the second part of the question are coded and presented in Table 5. The table presents the number of students' responses falling into each coding category for this question.

Table 5
Number of Students Responding, by Category, to Explanation of Why Feelings about Math Changed During the Semester Enrolled in Course

Category	Number (n = 5)
More comfortable/confident with math	2
Enjoyable class with fun activities	3
Could now teach math to elementary students	2
Better understanding of math/visualization	4

Note: Student responses may fall into more than one category.

Students were then asked the following question: *Was this course different than previous college math courses you have taken? If so, explain including telling whether it has been different in a positive or negative way.* Four of the five students stated that the course was different from previous college math courses and it was different in a positive way. One student had been enrolled in special sections of college algebra and the survey course, which were specifically taught for education majors. She did not think this course was completely different than previous college math courses. This student did indicate that the problem-solving course was more "hands-on" than the other courses and that is included in the coded responses in Table 6.

Table 6
Number of Students Responding, by Category, to Explanation of How the Problem Course was Different than Previous College Math Courses

Category	Number (n = 5)
Hands-on/use of manipulatives	4
Course that didn't just teach formulas	2
Relevant to real life	1
More explanatory	4
Lower level of math/taught basics of math	2

Note: Student responses may fall into more than one category.

In examining the responses to the two previously asked questions, more responses were coded for "better understanding of math/visualization" in respect to why their feelings about math changed during the semester. The most responses were coded for "hands-on/use of manipulatives" and "more explanatory" as to how the problem solving and number sense course was different from previous college math courses. It seems obvious that "better understanding" would follow from "more explanation," but "more explanation" may not have occurred during previous college courses taken by these students in light of the students' initial level of mathematics anxiety upon entering the course.

Three of the five students used some form of the word "nervous" when asked what they thought is meant by math anxiety. Anne and Donna said it is a "nervousness about math." Bonnie said it is being "nervous about tests" and having a "low self-esteem about math." Carolyn said she thought math anxiety was "apprehension towards anything that involves the mathematical way of thinking." Emma responded that math anxiety is "the stress that comes along with the subject."

The students were asked if they liked math with a follow-up question of why or why not. Three of the five responded that they did not like math. Interestingly, two of the three had positive comments about math beyond the initial response of "no." Anne commented that she thinks "it will be exciting to teach the lower levels of math." Carolyn commented that she likes to watch Discovery Channel programs dealing with physics and quantum mechanics. She stated that "complicated math concepts seem to click with me, but the basic math concepts do not seem to stick in my head." The third person responding "no" was Donna. She stated that she "has never really done well in

math" and "it may have had something to do with teachers." Bonnie responded that she "sort of" liked math in the respect that she likes it more now than she did prior to the problem solving course. When asked why she likes it more now, the student responded that she doesn't necessarily think math is easier now but believes she can see it better because of the physical use of the manipulatives. She commented that "the visual is important." Emma stated that she likes it now – after the problem-solving course. She said she believed having math explained in different ways helps; she now understands it better and enjoys it.

Next, if the students responded "no" to the previous question of whether they liked math, they were asked if they have ever liked math with a follow-up question of what caused them to like math. If the students responded "yes" to the previous question of whether they liked math, they were asked if they have ever disliked math with a follow-up question of what caused them to dislike math. Two of the five students responded "yes" that they had liked math at some point in time. Anne commented that she liked it for a couple of years in high school when she was making A's. She stated that she believed the teachers caused her to like math because they explained the math well and made them "have fun with it." Carolyn again said that she likes math "as it pertains to higher scientific concepts" and for "its practicality and logic." She appreciates math, but does not enjoy actually doing the math. Emma was the only student who had initially responded "yes" to if she liked math. When asked if she ever disliked math, she responded "yes." Emma referred back to her middle school years when she felt liked she had "crummy" teachers. One specific teacher had her repeat pre-algebra in the next grade and Emma thought this was a wasted year in math.

DISCUSSION

A common thread in responses to most questions was “the teacher.” When asked to give a reason for their entry level of mathematics anxiety, most attributed it to poor teachers. When asked to give a reason for their exit level of mathematics anxiety, one of the most common reasons given was the way the teacher taught the material. Another common reason given was the use of different solving methods which indirectly refers back to “the way the teacher taught the material.”

The five preservice teachers reported that their feelings changed in a positive manner over the duration of the semester and most believed it was because they had a better understanding of the mathematics and were able to visualize the mathematics. Three students commented that it was an enjoyable class with fun activities. When asked how the course was different from previous college mathematics courses, most responded that it was taught in a more explanatory way and was taught hands-on through the use of manipulatives. Note that all comments indirectly refer back to “the way the teacher taught the material.”

The preservice teachers were asked questions about their like and/or dislike of mathematics. Although most stated that they disliked mathematics, three of the five had positive comments concerning mathematics including thinking that basic math will be exciting to teach. One student who disliked math believed the dislike of math stemmed from a negative experience with a seventh grade math teacher. Again, the common thread of “the teacher” appears.

If the content of a mathematics course is taught in a more explanatory way, it seems obvious that the students would have a better understanding of the material. But, it might

appear that the more explanatory way may not have occurred during previous college mathematics courses taken by these five preservice teachers in light of their initial level of mathematics anxiety upon entering the problem solving course. It was this "more explanatory way" that most believed caused their feelings about mathematics to positively change over the semester.

These five preservice elementary teachers were interviewed to ultimately determine what instructors of preservice teachers can do to positively change their students' feelings about mathematics. This study has indicated that teachers should explain the material thoroughly using hands-on activities that are enjoyable. Future research should probe further and determine exactly what teaching methods were used, how these methods were implemented, and what made these methods enjoyable.

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