

**“Math makes me sweat”
The Impact of Pre-Service Courses on Mathematics Anxiety**

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Abstract

We investigate mathematics anxiety amongst education majors currently enrolled as pre-service teachers in special education, deaf and hard of hearing, early childhood and elementary education. The impact of a compulsory freshmen content course and sophomore methodology course on mathematics anxiety for each education major was studied over a two year period. Results indicate that the highest level of mathematics anxiety, as measured by the Revised-Mathematics Anxiety Survey (R-MANX), occurred amongst pre-service deaf and hard of hearing teachers as they enter their training as teachers. Results reveal that certain education majors benefit more than others from mathematics training courses.

Introduction

“Math makes me sweat” - This comment of a freshmen education major, when asked about her feelings about mathematics and the upcoming expectation to teach mathematics, and many other similar comments over years of preparing teachers to teach mathematics, sparked for us the question of the level of mathematics anxiety amongst prospective teachers of children in early childhood, elementary school, students with special needs and the deaf and hard of hearing. We are concerned about the possible effects of mathematics anxiety of pre-service teachers on their future classrooms, with possible impact on the attitude and performance of their students. We agree with Reichwein Zientek, Yetkiner and Thompson (2010) that believe it is valuable to investigate whether pre-service teachers’ mathematics anxiety levels are associated with areas of certification preparation (e.g., early childhood) or by the courses in which the teachers are enrolled. We investigated three research questions relating to the difference in mathematics anxiety amongst students of different education majors as reflected on the Revised-Mathematics Anxiety Survey (R-MANX) as they enter their training as teachers; the impact of a freshman level mathematics content course and a sophomore mathematics methodology course in reducing mathematics anxiety.

What is Mathematics Anxiety?

Gresham (2007b) describes mathematics anxiety as feelings of helplessness, tension, or panic when performing mathematics operations or problems. According to Geist (2010) attitudes toward mathematics are set because of prior experiences. Jackson and Leffingwell (1999) found that teacher behavior was a prime determinant of mathematics anxiety and that it is usually evident early on in the primary grades. They link mathematics anxiety to prior formal instruction with 16% of students reporting their first negative mathematics instruction experience in grade three or four. Students characterize teachers as being either hostile or insensitive as demonstrated

by derogatory comments in front of peers, and demonstrating impatience when students requested assistance. Hembre (1990) believes that mathematics anxiety is a learned condition, with Wadlington and Wadlington (2008) adding, that it interferes with an individual's ability to learn mathematics.

Mathematics Anxiety and Teachers

Gresham (2007a) and Geist (2010) believe that many teachers who have mathematics anxiety themselves not only influenced but inadvertently pass it on to their students and Beilock, Gunderson, Ramirez and Levine (2010) believe that that their anxiety could negatively impact their students' mathematics achievements. Bursal and Paznokas (2006) found negative correlations between preservice teachers' mathematics anxiety and their confidence to teach elementary mathematics with Beilock et al. (2010) showing that just one elementary school year with a mathematics anxious teacher led to lower mathematics achievement (especially for girls) and the forming of commonly held gender related beliefs about who is good in mathematics (boys vs. girls). Swetman, Munday, and Windham (1993) discovered that elementary school teachers with high levels of mathematics anxiety spend less time planning mathematics lessons and use mathematics instruction time for non mathematics related activities. Brady and Bowd (2005) also found that 39.3% of prospective elementary school teachers report that mathematics was their least liked subject and that many teachers uncomfortable teaching mathematics because they do not like mathematics themselves (Geist, 2010). Hembre (1990) in a meta-analysis of 151 studies found that elementary education students exhibited the highest level of mathematics anxiety when compared to other undergraduate majors (e.g. humanities or social science). He also discovered that students enrolled in mathematics courses for elementary teachers revealed the highest level of mathematics anxiety, higher than those students enrolled in courses such as "Remedial Algebra" or "Developmental Mathematics". Reichwein Zientek et al. (2010) found that early childhood teacher education majors exhibit anxiety levels somewhat comparable to those of community college remedial mathematics students.

Purpose of the Study and Research Questions

Limited research however exists regarding the effectiveness of a mathematics content course and method course in reducing the levels of mathematics anxiety among pre-service teachers especially pre-service teachers of special education or deaf and hard of hearing students. We investigated the following three research questions: Is there a difference in mathematics anxiety amongst students of different education majors as reflected on the Revised-Mathematics Anxiety Survey (R-MANX) as they enter their training as teachers?; Does a freshman level mathematics content course reduce the mathematics anxiety for all education majors or only certain subgroups?; Does a sophomore mathematics methodology course reduce mathematics anxiety for all education majors or only certain subgroups?

Methodology

Participants. Participants in this two year study were freshman or sophomore pre-service education majors with focus on Elementary (n=210), Early Childhood (n=106), Special Education (n=59) or Deaf and Hard of Hearing (n=46) at a public liberal arts college on the East Coast. As part of their graduation requirements, all students must complete both a mathematics content and methodology course. In the freshmen content course students are engaged in a thorough development of patterns, numeration, mathematical systems, real numbers, and number theory. The course aims to assist students in the development of a deep understanding of the

processes and algorithms found in elementary mathematics and discover purposes beneath the symbols and techniques. The exploration of fundamental concepts in these areas is complimented with physical materials and models. An important requirement is that students engage in problem solving, reason mathematically, use a variety of representations of mathematical concepts and procedures and communicate mathematics effectively at different levels of formality. The sophomore methodology course examines the early childhood and elementary mathematics curricula, how children learn mathematics, methods and strategies appropriate for teaching the many topics in mathematics. Students are introduced to national and state standards for preK-5 mathematics, and learn how to teach according to these standards. Topics include the use of manipulatives and technology in teaching mathematics, learning theories, and the investigation of standards-based curricula.

Instrumentation and procedure. To assess the level of mathematics anxiety, all pre-service education majors enrolled in either class during the two year study period were asked to voluntarily complete the R-MANX survey at the beginning and end of their compulsory freshmen content and sophomore methodology course. The R-MANX contains 30 items in which students respond on a scale from 1 (no anxiety) to 5 (high anxiety). Possible scores range from 30-150 where higher scores indicate higher mathematics anxiety. Items asked the student to define their level of mathematics anxiety when dealing with daily situations and their own coursework. The test items were developed by Bursal and Paznokaz (2006) from the 45 item Mathematics Anxiety Survey (MANX).

For ninety-five of these students, the R-MANX yielded a total of four measurement points, allowing for two pre-post pairings (one for each course). Some students, including transfer students, only completed the survey for one course. In addition, this investigation excluded Mathematics or Mathematics/Science/Technology (MST) majors because the Mathematics majors are only required to complete the methodology course and the MST majors are required to take far more mathematics courses than the other majors in this study.

Results

Initial Levels of Mathematics Anxiety. The box plot and summary statistics (see Figure 1 and Table 1) illustrate the differences in initial mathematics anxiety between the Elementary (ELEM), Early Childhood (EACH), Special Education (SPED) and Deaf and Hard of Hearing (DEAF) pre-service teachers as students entered teacher training. These results reveal that the DEAF pre-service teachers had the highest initial mean mathematics anxiety level, 93.43, while ELEM pre-service teachers had the lowest mean mathematics anxiety level, 81.18.

These summary statistics affirm that there is a difference in mathematics anxiety amongst students of different education majors as they enter their training. A follow-up analysis of variance, ANOVA, also confirmed that there was a statistically significant difference ($p=0.003$) in the initial mean mathematics anxiety level between pre-service teachers in the different education majors, see table 2 below. Therefore, it is appropriate that any analysis considers these four subpopulations separately to evaluate the effectiveness of these two courses on reducing a pre-service teacher's mathematics anxiety.

Figure 1: Mathematics Anxiety Levels of Pre-Service Teachers Entering Initial Mathematics Training Course

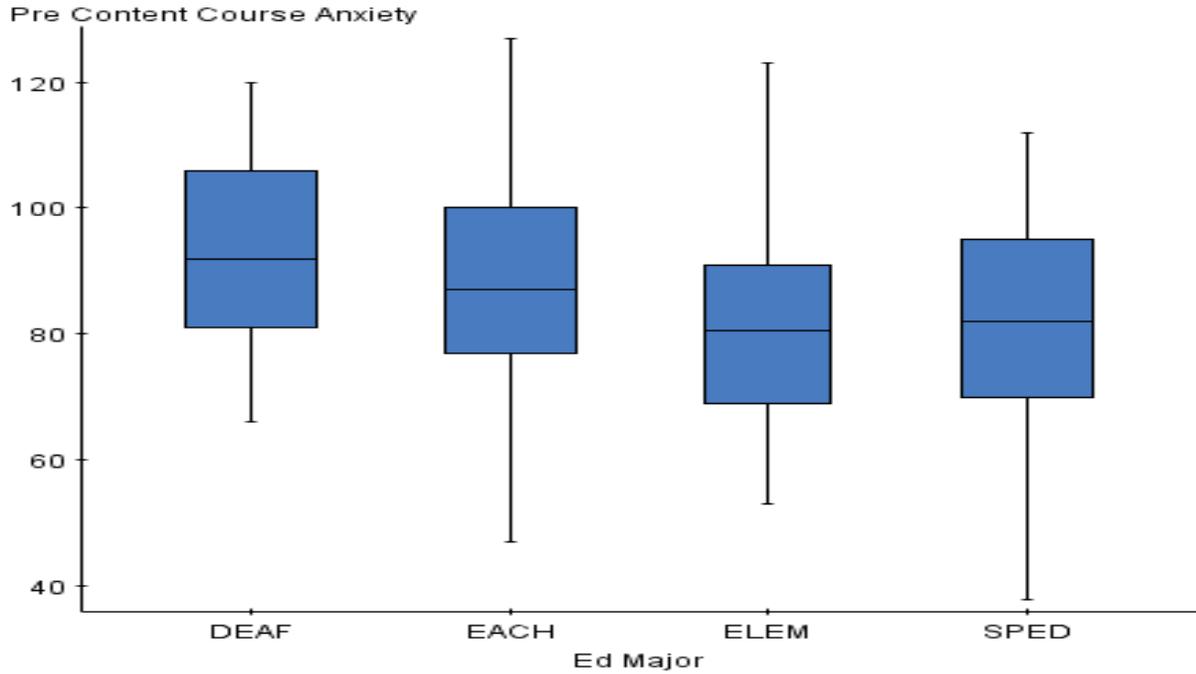


Table 1: Summary Statistics for Pre Content Course Mathematics Anxiety Level by Education Major

Ed Major	n	Mean	Std. Dev.	Median	Min	Max	25% Percentile	75% Percentile
DEAF	30	93.43	14.62	92	66	120	81	106
EACH	57	88.14	16.80	87	47	127	77	100
ELEM	114	81.18	14.34	80.5	53	123	69	91
SPED	37	81.54	17.00	82	38	112	70	95

Table 2: ANOVA Results for determining a difference between initial mathematics anxiety levels by major

Source of Variation	Degrees Of Freedom	F-Stat	P-value
Between majors	3	6.623487	0.0003
Residual	234		
Total	237		

Impact of Content Course on Mathematics Anxiety. To evaluate the effectiveness of the freshman content course (our second research question); we examined the mean change in mathematics anxiety (pre – post content course) for 205 pre-service teachers that completed the R-MANX. The content course, using the total sample, significantly ($p = 0.0004$) reduced mathematics anxiety of pre-service teachers (see Table 3). However, these results do not take into consideration differences in the four sub-populations of this group. This sample of 205 pre-service teachers was partitioned by education major.

Table 3: Hypothesis Test Results – Content Course for All Pre-Service Teachers

Variable	Sample Mean	Std. Err.	n	T-Stat	P-value
Mean Change in Mathematics Anxiety Before and After Content Course	2.79	0.81	205	3.43	0.0004

A further analysis of this data revealed that the ELEM pre-service majors were the only sub-population to exhibit a statistically significant ($p=0.0002$) decrease in mean mathematics anxiety after completing the content course. This result demonstrates the need to examine the impact of these courses on each of the sub-populations instead of the group as a whole.

Table 4: Hypothesis Test Results – Content Course for Pre-Service Teachers by Education Major

Ed Major	Sample Diff.	Std. Err.	n	T-Stat	P-value
DEAF	1.1666666	2.6131403	24	0.44646153	0.3297
EACH	1.875	1.7495251	48	1.0717194	0.1447
ELEM	3.5742574	0.9887833	101	3.6148036	0.0002
SPED	2.9375	2.6407697	32	1.1123651	0.1373

Impact of Methodology Course on Mathematics Anxiety. Similarly, a comparison of subpopulations in the methods course revealed that EACH majors had the highest level of mathematics anxiety and ELEM had the lowest initial mathematics anxiety level when entering the sophomore methodology course, see Table 5 below.

Table 5: Summary statistics for Pre Methods Course Mathematics Anxiety by Education Major

Ed Major	n	Mean	Std. Dev.	Median	Min	Max	25% Percentile	75% Percentile
DEAF	19	80.1579	14.318842	79	53	108	71	90
EACH	57	86.649124	17.880049	86	53	130	73	97
ELEM	99	79.93939	18.141068	78	43	126	68	92
SPED	22	81.181816	19.536623	78	40	120	69	96

The effectiveness of the sophomore methodology course (our third research question), using the mean change in mathematics anxiety (pre-post method course), for the 179 pre-service teachers, showed that the course significantly ($p = 0.0003$) reduced mathematics anxiety (see Table 6).

Table 6: Hypothesis Test Results – Methods Course for All Pre-Service Teachers

Variable	Sample Mean	Std. Err.	n	T-Stat	P-value
Mean Change in Mathematics Anxiety Before and After Method Course	2.52	0.72	179	3.50	0.0003

However, an analysis of each of sub-populations (Table 7) revealed that the method course resulted in a statistically significant decrease in the mean mathematics anxiety level for the DEAF ($p=0.029$), EACH ($p=0.0084$) and ELEM ($p=0.0183$) pre-service majors but not for the SPED pre-service teachers ($p=0.407$).

Table 7: Hypothesis Test Results – Method Course for Pre-Service Teachers by Education Major

Ed Major	Sample Diff.	Std. Err.	n	T-Stat	P-value
DEAF	3.1666667	1.5577133	18	2.0328944	0.029
EACH	3.8653846	1.5633985	52	2.4724245	0.0084
ELEM	2.0674157	0.9744957	89	2.1215236	0.0183
SPED	0.5	2.095735	20	0.23857978	0.407

Impact of Content Course and Methodology Course on Mathematics Anxiety. Finally, to determine the effectiveness of the two course sequence, we examined the mean change in mathematics anxiety for 95 students that completed the R-MANX survey at the beginning of their content course and at the end of their methods course. This analysis revealed that this two course sequence resulted in a statistically significant decreased ($p=0.004$) in the mean mathematics anxiety level when using the entire sample (see Table 8).

Table 8: Hypothesis Test Results – Two Course Sequence for All Pre-Service Teachers

Variable	Sample Mean	Std. Err.	n	T-Stat	P-value
Mean Change in Mathematics Anxiety After Two Course Sequence	3.93	1.13	95	3.45	0.0004

There was only a decrease in mathematics anxiety for the DEAF ($p=0.022$) and ELEM ($p=0.0039$) pre-service majors but not for the EACH or SPED pre-service teachers (see Table 9).

Table 9: Hypothesis Test Results – Two Course Sequence for Pre-Service Teachers by Education Major

Ed Major	Sample Diff.	Std. Err.	n	T-Stat	P-value
DEAF	7.5	3.299449	12	2.2731068	0.022
EACH	3.5652175	2.8540423	23	1.2491816	0.1124
ELEM	4.5897436	1.6337029	39	2.8094115	0.0039
SPED	1.0952381	2.027084	21	0.5403022	0.2975

Discussion and Scholarly significance

Results from our first research question are of great significance to the training of pre-service teachers. The high level of mathematics anxiety of all pre-service teachers, irrespective of educational major, should be of major concern to colleges/universities, schools and parents, especially in light of the possible impact a mathematics anxious teacher could have on future classes and, student attitudes and achievement. Special care should be taken to determine, early in pre-service training, the level of mathematics anxiety amongst pre-service teachers and to actively work towards reducing mathematics anxiety levels while adequately preparing them for the demands of teaching.

Our second research question made it evident that a general “one size fits all” mathematics content course designed for all PreK-5 teachers did not contribute to reducing mathematics anxiety of early childhood, deaf and hard of hearing or special education pre-service teachers. The methodology course, the focus of our third research question, did not reduce the anxiety for the pre-service special education teachers. Thus neither course had an impact on the mathematics anxiety level of pre-service special education teachers. This result may not be surprising as there has been some disagreement on the how students with special needs should be taught mathematics. Jordan, Allsopp and Eisele (1996) found that mathematics educators focus on student-centered learning practices (e.g. discovery learning, inquiry-based learning) while special educators focus more on direct instruction practices. These researchers advocate the incorporation of the essential aspects of both student-centered and teacher directed mathematics instructional practices.

Conclusions

The results of this study identify a lack of the current system of mathematics teacher preparation that does not assist in the reduction of mathematics anxiety, especially for the teachers of students with special needs. The system therefore fails to prepare prospective teachers to meet the needs of diverse learners. We are advocating for implementing greater use of concrete manipulatives (Sovchik, Meconi, & Steiner, 1981; Thompson, 1992) and an increased emphasis on conceptual understanding (Bursal & Paznokas, 2006; Hembree, 1990; Tobias, 1998; Vinson, 2001) as it has been found to lead to a reduction in pre-service teachers’ mathematics anxiety levels. We are also advocating for a greater emphasis and focus, in methodology classes, of the specialized needs of students in special education, and deaf and hard

of hearing students. The need to include instructional methods that would address the needs of teachers wanting to focus on students with special needs (special education and deaf and hard of hearing) is clear, if we, as educators of teachers, are to reduce the mathematics anxiety of all pre-service teachers.

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