

Mathematics Anxiety and Mathematical Beliefs: What Is the Relationship in Elementary Pre-Service Teachers?

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Abstract

Three hundred-one pre-service teachers enrolled in elementary teacher education program were administered two surveys to measure mathematics anxiety and mathematical beliefs. Results of the study revealed that there were significant differences between third year and fourth year pre-service teachers regarding their mathematics anxiety and mathematical beliefs. They held strong beliefs about teaching and learning mathematics that were aligned with the teacher education program. The results suggested that the pre-service teachers who held stronger beliefs and felt less anxious were more confident about their abilities to teach mathematics effectively. Thus, the significant relationship between mathematics anxiety and mathematical beliefs should be acknowledged.

Key words: mathematics anxiety, mathematical beliefs, pre-service teachers.

Introduction

The constructs, anxiety and belief are of great interest to researchers attempting to understand teaching and learning of mathematics (Briley, 2012; Brown et al., 2011; Hart, 2002; Kelly & Tomhave, 1985; Levine, 1996; Philipp, 2007; Sloan, 2010). The predominant approach used by researchers to measure these constructs is to determine how mathematics anxiety and mathematical beliefs affect pre-service teachers' teaching practices. For decades, research studies have examined factors that contribute to pre-service teachers' anxiety and beliefs regarding mathematics and ways to address issues rise in teacher education programs. Research (Bekdemir, 2010; Uusimaki & Nason, 2004; Malinsky, Ross, Pannells & McJunkin, 2006) suggested that pre-service teachers' negative school experiences could be the reasons for the sources of their negative beliefs and anxiety. A few studies showed that less is known about pre-service teachers' mathematical beliefs as a result of their prior experiences, and in particular, a lesser known construct, their anxieties regarding mathematics teaching (Briley, 2012; Levine, 1993; Peker, 2009). Therefore, this present study examines the relationship between mathematics anxiety and mathematical beliefs of elementary pre-service teachers.

Mathematics Anxiety. Research studies relating to teaching methodology suggested that pre-service teachers with high levels of mathematics anxiety are likely to pass their own anxieties to students (Bulmahn & Young 1982; Martinez 1987). Some researchers have presented disturbing information indicating that pre-service teachers with high level of mathematics anxiety actually teach differently than pre-service teachers who held a low level of mathematics anxiety. In essence, studies have shown that pre-service teachers with high level mathematics anxiety have a slight tendency to use inappropriate teaching approaches and whole-group instruction while spending less time to teach mathematical concepts (Ameen et al., 2002; Bush, 1989; Levine, 1993; Peker, 2009; Peker & Ertekin, 2011). Schmidt and

Buchmann (1983) suggested that teachers who like mathematics spend 50 percent more time than teachers who do not like this subject area. In the same way, Bulmahn and Young (1982) have suggested that pre-service teachers who do not enjoy mathematics in the broad-sense from its logical beauty to real life applications identified mathematics as their worst subject among the courses they were expected to teach when they become an elementary teacher (Bulmahn & Young, 1982). Consequently, studies have examined the prevalence and underlying cause of mathematics anxiety in pre-service teachers (Brown et al., 2011; Levine, 1993, 1996; Peker, 2009; Peker & Ertekin, 2011). Unfortunately, results of the research studies suggested that the pre-service teachers' negative experiences as a student, lack of support from their families and effect of their previous mathematics classes might be the reasons for their anxiety (Uusimaki & Nason, 2004; Malinsky et al., 2006). Additional research has indicated that pre-service teachers with high level of mathematics anxiety have lack of confidence in their abilities to teach elementary mathematics effectively (Bursal & Paznokas, 2006). Studies relating to mathematics teaching methods courses reported that introduction of the theoretical aspect of mathematical concepts increased elementary pre-service teachers' anxiety level and yet use of manipulatives in planning student-centered teaching decreased their anxiety (Battista, 1986; Hembree, 1990; Harper & Daane, 1998; Bursal & Paznokas, 2006; Vinson, 2001; Gresham, 2007).

Mathematical Beliefs. Pre-service teachers' beliefs are considered as one of the most important constructs in teacher education (Kagan, 1992; Pajares, 1992). The beliefs that pre-service teachers bring with them into their teacher education programs are strongly related to the form of learning and teaching they have been acquired over the years from their experiences in school settings (Richardson, 2003). Thus, changes in pre-service teachers' beliefs are difficult since the strength of preexisting beliefs that pre-service teachers bring into the teacher education programs held a potential inappropriateness in learning to teach. In other words, their entering perspective on teaching and learning affect how and what they teach in classroom (Richardson, 2003; Ball, Lubienski, & Mewborn, 2001; Pajares, 1992; Thompson, 1992). Therefore, the courses offered by teacher education programs intend to challenge pre-service teachers' beliefs through classroom readings, discussions and field experiences. As a part of the programs, mathematics teaching methods courses are designed as a reflective task to enhance connections between theory and practice since pre-service teachers' beliefs have mediating effect on their decisions for selecting appropriate teaching approaches in classroom (Pajares, 1992; Philipp, 2007; Philipp, et al., 2007; Thompson, 1992). For instance, pre-service teachers who believe that student-centered approach brings about greater benefits than teacher-centered approach would tend to include more collaborative work than pre-service teachers who see little or no teaching value in cooperative learning.

Teacher education programs intend to prepare elementary pre-service teachers to develop knowledge and skills for teaching mathematics effectively since they are expected to be competent in many aspects of teaching profession. Still, it is rather difficult for pre-service teachers to genuinely know and work with students in actual classroom. When it comes to teaching, pre-service teachers are concerned about how they would be seen, what they would do or say when they are placed in the classroom environment for mathematics teaching (Peker, 2009). As seen in the literature, the constructs, mathematics anxiety and mathematical beliefs have major influences on establishing pre-service teachers' professional development. However, a few study examined the relationship between mathematical beliefs and mathematics anxiety of pre-service teachers (Brown et al., 2011; Swars, et al., 2009).

It does appear that mathematics anxiety might be linked to pre-service teacher's mathematical beliefs. Therefore, the purpose of this research study was to investigate the

following research questions: (1) Is there a significant difference in mathematics anxiety and mathematical beliefs scores of elementary pre-service teacher with respect to numbers of years spent in college? (2) What is the relationship between elementary pre-service teachers' mathematics anxiety and mathematical beliefs?

Method

Participants. The participants were 301 pre-service teachers enrolled in elementary pre-service teacher education program. The sample consists of 200 females and 101 males. The samples involved 135 fourth year and 166 third year pre-service teachers. At the time of the study, the pre-service teachers who were in the third year of the program completed mathematics education methods courses. The pre-service teachers who were in the fourth year of the program had taken mathematics education methods courses and completed their internship at an elementary school.

Instruments. The Mathematics Anxiety Rating Scale-Short Version (MARS-SV) was developed by Suinn and Winston (2003) to measure the pre-service teachers' mathematics anxiety. The instrument was adapted to Turkish by Baloglu (2010). The MARS-SV consists of 30 items on a five-point Likert type of scale. Within this scale, MARS-SV includes 5 broad dimensions: test, course, application, computation and social anxiety. The reliability coefficient for the overall instrument was calculated as .93. The cronbach alpha reliability coefficient was calculated as 0.86 for mathematics test anxiety, 0.85 for course anxiety, .92 for application anxiety, 0.92 for computation anxiety and 0.88 for social anxiety subscales. In the present study, pre-service teachers were asked to indicate the extent to which they felt anxiety on a five point Likert scale anchored at points with the statements: *not at all*, *very little*, *somewhat*, and *very much*. Higher scores reflect lower level of mathematics anxiety.

Additionally, the Mathematical Beliefs Instrument (MBI) developed by Peterson, Fennema, Carpenter and Loef (1989) was used in this study. The instrument was adapted to Turkish culture by Haciomeroglu (2012). This instrument was adapted to Turkish culture to examine pre-service teachers' mathematical beliefs about learning and teaching. The adapted instrument includes 34 items in a five-point likert-type of instrument ranging from "strongly agree" to "strongly disagree". Within this adapted instrument, MBI consists of 4 broad dimensions: (1) Beliefs about how students construct mathematical knowledge, (2) beliefs about teaching mathematical concepts, (3) beliefs about organization of teaching, and (4) beliefs about students' development of mathematical knowledge. The cronbach alpha reliability coefficient was calculated as 0.82 for beliefs about how students construct mathematical knowledge, 0.78 for beliefs about teaching mathematical concepts, 0.75 for beliefs about organization of teaching, and 0.73 for beliefs about students' development of mathematical knowledge subscale.

Procedure. In this study, Mathematics Anxiety Rating Scale Short Version (MARS-SV), and Mathematical Belief Instrument (MBI) were administered to 301 elementary pre-service teachers from a university located in northwest part of Turkey. Pre-service teachers who agreed to be part of this study were given these two instruments to complete during their regular class hours. It took them approximately 20-25 minutes to complete the instruments.

Data Analysis. Descriptive and inferential statistics were used for the analysis of mathematics anxiety and mathematical beliefs scores of elementary pre-service teachers. An independent-samples t-test was conducted to determine the differences between the third year and the fourth year elementary pre-service teachers' mathematical beliefs and mathematics anxiety. Since male pre-service teachers were close to half of the female pre-service teachers, an

independent t-test was not used to examine the difference between mathematics anxiety and mathematics teaching anxiety scores of pre-service teachers regarding gender. In addition, elementary pre-service teachers' mathematics anxiety scores were used to assign them into three groups: low, moderate and high. The classifications of the pre-service teachers were determined using quartiles of the mathematics anxiety scores. Pre-service teachers fell between 25% and 50% were considered the moderate group. Low and high mathematics anxiety group include pre-service teachers whose scores were in the lower 25% and in the upper 25% of the distribution. The Pearson product correlation coefficients of the pre-service teachers MBI and MARS were calculated to explain the possible relationships between these variables. One-way ANOVA and Tukey HSD (Honestly Significant Differences) tests were used to compare the mean MBI scores of the different mathematics teaching anxiety groups.

Findings

The participants' scores on the MARS and the MBI were analyzed by using descriptive and inferential statistics. Descriptive analysis of the mathematical beliefs instrument indicated generally positive beliefs expressed by the pre-service teachers regarding mathematics teaching and learning. Their responses to subscales of MBI revealed that they had strong beliefs about how students construct mathematical knowledge ($M=3.88$; $SD=.43$), teaching mathematical concepts ($M=4.15$; $SD=.51$), and students' development of mathematical knowledge ($M=3.80$; $SD=.50$). These findings showed that pre-service teachers were generally confident about their abilities to teach mathematics effectively. However, pre-service teachers held a low level of mathematical beliefs regarding organization of teaching ($M=3.05$; $SD=.63$). This finding demonstrated that pre-service teachers were not confident about their belief regarding organization of teaching.

The pre-service teachers' responses to MARS revealed that they held a low level of mathematics anxiety regarding test ($M=3.48$, $SD=.88$), course ($M=3.96$, $SD=.77$), application ($M=4.23$, $SD=.66$), computation ($M=4.78$, $SD=.48$), and social ($M=4.52$, $SD=.66$). Over all, the results posited that the pre-service teachers felt less anxious about mathematics.

Table 1.

Independent t-test results for pre-service teachers scores on the subscales of MBI regarding year spent in the program

Subscales of MBI	Year	N	Mean	SD	p
Beliefs about how students construct mathematical knowledge	3rd	166	3.88	.40	.94
	4th	135	3.88	.46	
Beliefs about teaching mathematical concepts	3rd	166	4.21	.44	.02*
	4th	135	4.07	.57	
Beliefs about organization of teaching	3rd	166	2.98	.60	.02*
	4th	135	3.15	.67	
Beliefs about students' development of mathematical knowledge	3rd	166	3.76	.48	.17
	4th	135	3.84	.54	

* $p < .05$ Note. The higher the Mathematics Belief Instrument score, the greater the mathematical belief.

An independent sample t test was conducted to determine differences between the third year and the fourth year pre-service teachers' mathematical belief scores. Results of the study revealed that there were no significant differences between the third year and the fourth year pre-service teachers regarding beliefs about how students construct their mathematical knowledge ($t=.71$, $p > .05$) and beliefs about students' development of mathematical knowledge ($t=-1.35$, $p > .05$). However, there was a significant difference between third year and fourth year pre-service teachers regarding beliefs about teaching mathematical concepts

($t=2.31$, $p<.05$) and beliefs about organization of teaching ($t=-2.32$, $p<.05$). For the beliefs about designing of teaching, fourth year pre-service teachers had stronger mathematical beliefs in comparison to the third year pre-service teachers. It seems third year pre-service teachers had a lack of confidence in their abilities to teach mathematics when their beliefs were related to students' development of mathematical skills.

Table 2.
Independent t-test results for pre-service teachers scores on the subscales of MARS regarding year spent in the program

Subscales of MARS-SV	Year	N	Mean	SD	p
MARStest anxiety	3rd	166	3.44	.90	.41
	4th	135	3.53	.86	
MARScourse anxiety	3rd	166	3.96	.77	.99
	4th	135	3.96	.76	
MARSapplication anxiety	3rd	166	4.26	.58	.41
	4th	135	4.19	.75	
MARScomputation anxiety	3rd	166	4.84	.32	.01*
	4th	135	4.71	.61	
MARSsocial anxiety	3rd	166	4.57	.58	.16
	4th	135	4.46	.75	

* $p<.05$ Note. The higher the MARS-SV score, the lower the math teaching anxiety.

An additional t test was conducted to determine differences between the third year and the fourth year pre-service teachers' mathematics anxiety scores. Results of the study revealed that there were no significant differences between the third year and the fourth year pre-service teachers regarding test, course, application and social. However, there was a significant difference between third year and fourth year pre-service teachers regarding computation ($t=2.36$, $p<.05$).

The results of the Pearson product-moment correlation revealed a small negative relationship between mathematics anxiety and mathematical beliefs among pre-service teachers when combining both subscales on MARS and MBI. There was no significant relationship between beliefs about organization of teaching and beliefs about students' development of mathematical knowledge subscales of MBI and subscales of MARS. There was a statistically significant relationship between Beliefs about how students construct mathematical knowledge and test, computation and social anxiety of MARS. The bivariate correlations between beliefs about teaching mathematical concepts and computation and beliefs about teaching mathematical concepts and social anxiety were significant at $r(301)=-.13$, $p<.05$ (two-tailed) and $r(301)=-.18$, $p<.05$ (two-tailed), respectively. The relationship between beliefs about how students construct mathematical knowledge and test ($r=-.12$, $p<.05$) and beliefs about how students construct mathematical knowledge and computation anxiety ($r=-.12$, $p<.05$) were found significant. Additionally, there was a significant relationship between beliefs about how students construct mathematical knowledge and social anxiety ($r=-.11$, $p<.05$). The correlation coefficient between pre-service teachers' MARS scores and their MBI scores is calculated to be $r=-.117$. The results of the Pearson product correlation coefficients of the pre-service teachers MBI and MARS showed that a small negative significant relationship was found between mathematics anxiety and mathematical beliefs scores of pre-service teachers. Results of the analysis demonstrated that the pre-service teachers with higher level of mathematics anxiety had lower mathematical beliefs and the pre-service teachers with low levels of mathematics anxiety had higher mathematical beliefs.

A one-way between groups analysis of variance was conducted to explore the impact of mathematics anxiety on levels of mathematical beliefs, as measured by the Mathematical Belief Instrument (MBI). Pre-service teachers were divided into three groups according to their mathematics anxiety scores: low ($M=3.83$, $n=75$), moderate ($M=3.74$, $n=149$) and high ($M=3.73$, $n=77$). Results of the analysis showed that there was a statistically significant difference at the $p<.05$ level in MBI scores for the three anxiety groups [$F(2, 298) = 3.607$, $p=.02$]. Despite reaching statistical significance, the actual difference in mean scores between the groups was quite small. The effect size, calculated using eta squared, was .02. According to Cohen's (1988), this value would be considered a small effect size. The resulting eta value is According to the Tukey's HSD tests, the mean differences in MBI scores between the low and moderate anxiety groups and between low and high anxiety groups were found to be statistically significant.

Discussion

This present study examined the relationship between mathematics anxiety and mathematical beliefs of elementary pre-service teachers. Pre-service teachers with lower levels of anxiety had higher mathematical beliefs. Pre-service teachers with higher mathematical beliefs have confidence in their own skills and abilities to be an effective elementary teacher. The findings of this present study support Swars et al. (2009) investigations of pre-service teachers' mathematics anxiety and mathematical beliefs. Pre-service teachers' mathematics anxiety had a negative relationship with their mathematical beliefs. For the participating pre-service teachers, mathematics anxiety was found to have a statistically negative relationship to the mathematical beliefs. The pre-service teachers had strong mathematical beliefs and felt less anxious about mathematics. The results of this study and previous studies (Briley, 2012; Swars et al., 2007; Swars et al., 2009) revealed that the pre-service teachers who held strong beliefs in their abilities to teach mathematics effectively were more likely to have more sophisticated mathematical beliefs. On the other hand, the pre-service teachers who experience less anxiety feel more capable of their abilities to teach mathematics effectively. The results from this study was supported by the other research studies indicating mathematics anxiety is a cause in pre-service teachers' lack of confidence in teaching practices (Gresham, 2009; Harper & Daane, 1998; Hembree, 1990). In addition, research suggested that pre-service teachers' participation in mathematics methods courses reduce their mathematics anxiety level (Battista 1986; Gresham 2007; Harper & Daane 1998; Tooke & Lindstrom 1998). Pre-service teachers with low mathematics anxiety are more confident to teach elementary mathematics than the pre-service teachers with moderate and high mathematics anxiety. As in the case of teaching mathematics, pre-service teachers with low anxiety claim that they can teach mathematics more effectively than the other pre-service teachers experiencing higher mathematics anxiety. Similarly, the finding of the present study is supported by the research studies (Brady & Bowd, 2005; Bursal & Paznokas, 2006) examining the pre-service teachers' mathematics anxiety and their confidence level to teach mathematics. Although the magnitude of the correlations between mathematics anxiety and mathematical beliefs is not very strong, the significant relationship between mathematics anxiety and mathematical beliefs should be acknowledged. In the same way, the results of Swars et al. (2009) study showed that there was a negative significant relationship between mathematics anxiety and mathematical beliefs. The pre-service teachers with low mathematics anxiety held beliefs that were more cognitively aligned. They also had more confidence about their abilities to teach mathematics effectively.

The results of the study showed that there were significant differences between third year and fourth year pre-service teachers regarding their mathematics anxiety and mathematical beliefs. This study suggested that pre-service teachers' participation in field experiences at

school settings might be the reason for the difference between their beliefs. Although they both completed mathematics teaching methods courses, the fourth year pre-service teachers had completed their internship at an elementary school. The third year pre-service teachers had attended school experience that involved their observation of learning and teaching environment at a school setting. In addition, the fourth year pre-service teachers had slightly higher computation anxiety in comparison to the third year pre-service teachers. In Turkey, pre-service teachers are required to take Public Employee Selection Exam (PESE) to become an elementary teacher at a public school. In order to become an elementary teacher at a public school, the fourth year pre-service teachers are expected to receive a high score on Public Employee Selection Exam (PESE). Therefore, they study for this exam throughout their last year in the program. This could be the reason for why the fourth year pre-service teachers have slightly higher computation anxiety than the third year pre-service teachers.

Teacher educators should recognize that mathematics anxiety plays a role in mathematical beliefs of elementary pre-service teachers. The constructs mathematics anxiety and mathematical beliefs have profound effect on pre-service teachers' learning to teach mathematics as well as their potential to become effective teachers for elementary grade level. Therefore, if teacher education programs intend to prepare pre-service teachers whose instructional practices are influenced by effective teaching approaches and current educational reforms, an important component of the program involving mathematics teaching methods courses and field experiences should focus on development of pre-service teachers' mathematical beliefs and reduction of their mathematics anxiety. It is also important that mathematics teaching methods courses should provide self-awareness of prior experiences among pre-service teachers since research has shown that pre-service teachers' participation in these courses decreases their mathematics anxiety levels (Battista, 1986; Hembree, 1990; Harper & Daane, 1998; Bursal & Paznokas, 2006; Vinson, 2001; Gresham, 2007). Thus, the study suggests that longitudinal research studies should be conducted with pre-service teachers to examine the development of their mathematical beliefs and its relations to mathematics anxiety. Future research is needed to determine how mathematics anxiety and mathematical beliefs influence pre-service teachers' instructional practices and subsequent student achievement.

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