IUMPST: The Journal. Vol 5 (Teacher Attributes), August 2012 [www.k-12prep.math.ttu.edu]
ISSN 2165-7874

The relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for elementary pre-service teachers

Jason S. Briley
University of North Alabama
Department of Mathematics
One Harrison Plaza
Florence, AL 35632
jsbriley@una.edu

Abstract

Ninety-five elementary pre-service teachers enrolled in a mathematics content course for elementary school teachers completed 3 surveys to measure mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs. The pre-service teachers who reported stronger beliefs in their capabilities to teach mathematics effectively were more likely to possess more sophisticated beliefs as well as were more likely to have more confidence in solving mathematics problems. Mathematical beliefs also had a statistically significant effect on mathematics teaching efficacy and on mathematics self-efficacy. Thus, the significant relationship between mathematical beliefs and mathematics teaching efficacy should be acknowledged by mathematics teacher educators.

Keywords: mathematics education, mathematics teaching efficacy, mathematics self-efficacy, mathematical beliefs, pre-service teachers

Introduction

In its vision statement of mathematics education, *Principles and Standards for School Mathematics*, the National Council of Teachers of Mathematics (NCTM, 2000) promotes students' active engagement in experiences that foster the learning of mathematical concepts with understanding. Therefore, teachers need to cultivate an environment for mathematical thinking by emphasizing the thinking processes of students rather than student performance (NCTM, 2000; Stipek, Givvin, Salmon, & MacGyvers, 2001). Yet, in order for this type of teaching and learning possibly to occur in the classroom, a teacher's mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs should be taken into consideration.

Theoretical Framework

Teacher efficacy was developed from the self-efficacy component of Bandura's (1986) social cognitive theory. Self-efficacy consists of two dimensions: efficacy expectations and outcome expectancies. An efficacy expectation is an individual's belief in his or her capability to execute a behavior successfully, whereas an outcome expectancy is his or her belief that the behavior will result in specific consequences (Bandura, 1986).

Based on Bandura's (1986) theoretical framework, teacher efficacy is defined as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783). Similar to the two dimensions of self-efficacy, teacher efficacy can be regarded as a two-dimensional construct that includes personal teaching efficacy, which is a teacher's belief in his or her teaching effectiveness, and teaching outcome expectancy, which is a teacher's belief that effective teaching can result in positive student learning outcomes regardless of external factors (Enochs, Smith, & Huinker, 2000; Swars, Hart, Smith, Smith, & Tolar, 2007). These two dimensions should be distinguished (Bandura, 1986), because a teacher might believe that effective teaching produces student learning, yet he or she might be uncertain about possessing the necessary abilities for effective teaching. Various researchers have documented that teacher efficacy is related to student achievement and motivation as well as to teacher behavior (Brown, 2012; Henson, 2002; Tschannen-Moran & Woolfolk Hoy, 2001). Teacher efficacy is associated with a teacher's effort, persistence, and resilience (Pendergrast, Garvis, & Keogh, 2011; Tschannen-Moran & Woolfolk Hoy, 2007), the use of a variety of instructional strategies (Riggs & Enochs, 1990), and the use of student-centered strategies (Czerniak & Schriver, 1994).

Teacher efficacy is conceived to be subject-matter specific (Tschannen-Moran & Woolfolk Hoy, 2001). In the domain of mathematics, mathematics teaching efficacy consists of two dimensions that are parallel to the two dimensions of teacher efficacy: personal mathematics teaching efficacy and mathematics teaching outcome expectancy (Enochs et al., 2000). Research on the mathematics teaching efficacy of elementary pre-service teachers has been limited. The results of several studies indicated a statistically significant increase in mathematics teaching efficacy upon completion of one methods course or a sequence of methods courses (Charalambous, Philippou, & Kyriakides, 2008; Huinker & Madison, 1997; Rethlefsen & Park, 2011; Swars et al., 2007; Utley, Moseley, & Bryant, 2005) as well as upon completion of a mathematics content course (Alsup, 2004). Mathematics teaching efficacy also was found to be associated with teachers' past experiences as learners of mathematics (Brown, 2012; Charalambous et al., 2008; Swars, 2005). In addition, mathematics teaching efficacy has been shown to have a statistically significant negative relationship with mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2008; Swars, Daane, & Giesen, 2006).

Of the different factors that might contribute to mathematics teaching efficacy, one is the mathematics self-efficacy of teachers. Self-efficacy can be a better predictor of behavior than actual capability, because it can influence what individuals do with the skills and knowledge they possess (Pajares, 2003; Pajares & Miller, 1995). Mathematics self-efficacy is defined as "a situational or problem-specific assessment of an individual's confidence in his or her ability to successfully perform or accomplish a particular [mathematical] task or problem" (Hackett & Betz, 1989, p. 262). The mathematics self-efficacy of undergraduate students enrolled in calculus was found to be higher than the mathematics self-efficacy of undergraduate students enrolled in developmental mathematics courses (Hall & Ponton, 2005). The mathematics self-efficacy of undergraduate students was a stronger predictor of solving mathematics problems than mathematics self-concept, prior experience with mathematics, perceived usefulness of mathematics, or gender (Pajares & Miller, 1994). Moreover, undergraduate students' confidence to solve specific mathematics problems was a stronger predictor of performance than their confidence to undertake mathematics-related tasks or their confidence to succeed in mathematics-related courses (Pajares & Miller, 1995). Researchers have demonstrated that most students inaccurately judged their performance, in which a majority of students overestimated their performance (Hackett & Betz, 1989; Pajares & Miller, 1994). For pre-service teachers, their mathematics self-efficacy might influence the amount of effort and persistence they display in successfully solving mathematics problems, which in turn might influence their mathematics teaching efficacy (Esterly, 2003).

Another factor that appears to contribute to mathematics teaching efficacy is the mathematical beliefs of teachers. Beliefs lie in the intersection of the cognitive and affective domains (De Corte, Op't Eynde, & Verschaffel, 2002). Beliefs are not altered easily (Kagan, 1992) and the earlier a belief is included in an individual's belief system, the harder it is to change (Pajares, 1992). Epistemological beliefs are an individual's beliefs concerning the nature of knowledge and knowing (Hofer & Pintrich, 1997). Thus, beliefs about mathematical knowledge might be conceived of as domain-specific epistemological beliefs (Gill, Ashton, & Algina, 2004).

One theoretical framework of mathematical beliefs was developed by Grouws, Howald, and Colangelo (1996), which complements previous research on epistemological beliefs by Perry (1970) and Schommer (1990). Grouws et al. (1996) proposed seven dimensions of mathematical beliefs, which can be grouped into four categories: the nature of mathematical knowledge, the character of mathematical activity, the essence of learning mathematics, and the usefulness of mathematics. The nature of mathematical knowledge includes the composition, the structure, and the status of mathematical knowledge. Mathematics might be viewed as isolated facts or as coherent concepts. The character of mathematical activity consists of doing mathematics and validating ideas in mathematics. Doing mathematics might be perceived as implementing procedures for results or as making sense of concepts. The essence of learning mathematics refers to whether mathematics is to be memorized or is to be understood. The usefulness of mathematics pertains to whether mathematics has value in everyday life. Each dimension spans a continuum that ranges from what is described as naïve beliefs to sophisticated beliefs. Similar to Schommer's (1990) conception of beliefs, beliefs are regarded as relatively independent, so that individuals can possess both naïve and sophisticated beliefs simultaneously.

Pre-service teachers enter a teacher education program with a set of predetermined beliefs about mathematics and the teaching and learning of mathematics (Kagan, 1992; Pajares, 1992; Philipp, 2007). These beliefs are based on their prior experiences as students (Cady & Rearden, 2007). Many pre-service teachers hold a traditional view of mathematics (Stipek et al., 2001). Mathematical knowledge is conceived of as a collection of unrelated facts and procedures rather than as coherent concepts (Grouws et al., 1996). Doing mathematics is to recall and obey the appropriate rules (Lampert, 1990). Moreover, mathematics is to be learned by memorization rather than by understanding and making sense of concepts (Schoenfeld, 1989).

Because traditional beliefs are contrary to the conceptualization of mathematics and mathematics learning advocated by the NCTM *Principles and Standards*, the mathematical beliefs of preservice teachers should be consistent with current reform ideals (Hart, 2002; Wilkins & Brand, 2004). Researchers have demonstrated an increase in the consistency of pre-service teachers' mathematical beliefs during methods courses that emphasized constructivist experiences in the classroom (Beswick, 2006; Hart, 2002; Swars et al., 2007; Wilkins & Brand, 2004). In addition, pre-service teachers progressed from a traditional conception of mathematics to a problem-solving conception of mathematics during a methods course that focused on problem solving and learning to think mathematically (Steele & Widman, 1997). However, other results have indicated that the mathematical beliefs of pre-service teachers did not change during a teacher preparation program (Esterly, 2003). Of practical importance, teachers' mathematical beliefs have been associated with their classroom practices (Stipek et al., 2001). Because beliefs might affect instructional practices (Kagan, 1992; Pajares, 1992), teachers' mathematical beliefs might play a significant role in attempting to change their classroom practices in order possibly to foster more learning of mathematics with understanding (Stipek et al., 2001).

Few researchers have examined simultaneously any combination of the mathematics teaching efficacy, the mathematics self-efficacy, and the mathematical beliefs of pre-service teachers. A statistically significant positive relationship was found between mathematical beliefs and mathematics teaching efficacy (Esterly, 2003; Swars et al., 2007), as well as between mathematical beliefs and mathematics self-efficacy (Esterly, 2003). Mathematical beliefs appeared to have a statistically significant effect on mathematics teaching efficacy, but not on mathematics self-efficacy (Esterly, 2003). A statistically significant positive relationship also was found between mathematics teaching efficacy and mathematics self-efficacy (Bates, Latham, & Kim, 2011). In a study of in-service teachers, a stronger positive relationship existed between mathematics teaching efficacy and mathematics self-efficacy than between mathematics teaching efficacy and teacher efficacy (Jansen, 2008). However, in another study, teacher efficacy, but not mathematics self-efficacy, was a statistically significant predictor of mathematics teaching efficacy (Esterly, 2003).

NCTM (2000) asserts that “students’ understanding of mathematics, their ability to use it to solve problems, and their confidence in, and disposition toward, mathematics are all shaped by the teaching they encounter in school” (pp. 16-17). One factor that might affect teacher behavior is teacher efficacy (Brown, 2012; Henson, 2002; Tschannen-Moran & Woolfolk Hoy, 2001). In the domain of mathematics, teachers’ mathematics teaching efficacy might be influenced by their mathematics self-efficacy and their mathematical beliefs (Esterly, 2003; Swars et al., 2007). Therefore, a clearer picture of the relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for pre-service teachers is needed, especially because few researchers have examined these three constructs at the same time. The purpose of the present study was to investigate the relationships among elementary pre-service teachers’ mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs. The research hypotheses examined were as follows:

1. Mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy are positively related.
2. Mathematical beliefs and mathematics self-efficacy are positive predictors of mathematics teaching efficacy.
3a. Mathematical beliefs have a significant effect on mathematics teaching efficacy.
3b. Mathematical beliefs have a significant effect on mathematics self-efficacy.

It was hoped that the results of the present study would expand the knowledge base of mathematics education in the interrelated areas of mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for elementary pre-service teachers. Because researchers have shown that mathematical beliefs might have a significant effect on mathematics teaching efficacy and on mathematics self-efficacy (Esterly, 2003), the importance of sophisticated mathematical beliefs should be acknowledged by mathematics teacher educators. Assuming that sophisticated beliefs are superior to naïve beliefs, the naïve mathematical beliefs of pre-service teachers need to be challenged and possibly changed, perhaps within a different type of classroom environment (e.g. Steele & Widman, 1997).

Method

Participants and Setting. The participants in the present study were 95 elementary pre-service teachers who were enrolled in four sections of Mathematics for the Elementary School Teacher during two semesters at a southeastern regional university. The convenience sample consisted of 87 females and 8 males. Eight of the participants were sophomores, 65 were juniors, and 22 were seniors. The mean age was 21.91 (SD = 3.73), with a range of 19 to 40 years. The results of independent samples t tests revealed no statistically significant differences in mathematics teaching efficacy, mathematics self-efficacy, or mathematical beliefs between the pre-service teachers enrolled in the fall semester (N = 49) and the pre-service teachers enrolled in the spring semester (N = 46), ps > .05. Thus, the responses of all participants were combined.

Mathematics for the Elementary School Teacher is a required mathematics course for the elementary pre-service teachers, having a prerequisite of three general education mathematics courses. This course is a content course in which upper elementary mathematics concepts are emphasized. This course was taught by two instructors in the Department of Mathematics, who used a combination of lecture and hands-on activities.

Instruments. Instruments used to study the course effects consist of the following:

Mathematics Teaching Efficacy Beliefs Instrument. The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) consists of 21 items, which are organized into two subscales: the Personal Mathematics Teaching Efficacy (PMTE) subscale and the Mathematics Teaching Outcome Expectancy (MTOE) subscale (Enochs et al., 2000). These subscales correspond to the two dimensions of teacher efficacy. The PMTE subscale consists of 13 items that relate to a pre-service teacher's belief in his or her capability to teach mathematics effectively. The MTOE subscale includes 8 items that relate to a pre-service teacher's belief that effective mathematics teaching can result in student learning. The items are rated on a 5-point Likert-format scale ranging from Strongly Disagree (1) to Strongly Agree (5). Higher scores on the PMTE subscale indicate stronger personal mathematics teaching efficacy, whereas higher scores on the MTOE subscale indicate greater expectations of student learning of mathematics. The Cronbach alpha for scores pertaining to the entire MTEBI was .81. The Cronbach alpha was .87 for the PMTE subscale scores and .67 for the MTOE subscale scores.

Mathematics Self-Efficacy Scale-Revised. To assess mathematics self-efficacy, the Problems subscale of the Mathematics Self-Efficacy Scale-Revised (MSES-R) was administered (Kranzler & Pajares, 1997). The MSES-R was derived from the Mathematics Confidence Scale (Dowling, 1978). The original Problems subscale consisted of 18 items, but five items were eliminated due to insufficient structure/pattern coefficients (Kranzler & Pajares, 1997). The participants rate their confidence to solve successfully problems related to elementary mathematics concepts. The 13 items are rated on a 5-point Likert-format scale ranging from No Confidence at all (1) to Complete Confidence (5). Higher scores on the Problems subscale indicate greater confidence in solving these mathematics problems. The Cronbach alpha was .78 for the Problems subscale scores.

Conceptions of Mathematics Inventory-Revised. To measure mathematical beliefs, the Conceptions of Mathematics Inventory-Revised (CMI-R) was administered (Briley, Thompson, & Iran-Nejad, 2009). The original CMI was based on Grouws et al.'s (1996) theoretical framework. The CMI-R contains 38 items grouped into three subscales. The four categories of the theoretical framework were collapsed into three subscales, based on previous analysis (Briley et al., 2009). The Nature of Mathematics subscale consists of 14 items, the Doing, Validating, and Learning Mathematics subscale consists of 16 items, and the Usefulness of Mathematics subscale consists of 8 items. The 38 items are rated on a 6-point Likert-format scale ranging from Strongly Disagree (1) to Strongly Agree (6). Higher scores indicate more sophisticated mathematical beliefs. The Cronbach alpha for scores pertaining to the entire CMI-R was .90. The Cronbach alpha was .79 for the Nature of Mathematics subscale scores, .79 for the Doing, Validating, and Learning Mathematics subscale scores, and .83 for the Usefulness of Mathematics subscale scores.

Data Collection. The three surveys were administered during the last 3 weeks of each of the two semesters. Demographic information of gender, age, and educational level also were collected as part of the surveys. The surveys were administered by the author. Participation was strictly voluntary. The present study had the institution's review board approval for research involving human participants.

Results

The means and standard deviations for the CMI-R subscales, the MSES-R Problems subscale, and the MTEBI subscales are presented in Table 1.

Table 1: Means, Standard Deviations, and Pearson Correlations of the CMI-R Subscales, the MSES-R Problems Subscale, and the MTEBI Subscales

Measure	1	2	3	4	5	6
1. Nature of mathematics	—					
2. Doing, validating, and learning mathematics	.60*	—				
3. Usefulness of mathematics	.60*	.73*	—			
4. MSES-R Problems subscale	.32*	.43*	.55*	—		
5. PMTE subscale	.41*	.66*	.64*	.48*	—	
6. MTOE subscale	.22	.34*	.25	.13	.07	—
M	66.00	80.72	42.24	52.92	53.44	29.98
SD	7.98	7.80	5.26	6.13	6.91	3.53

Note. **p* < .003.

Based on the means of the belief subscales, the participants, on average, somewhat less than agreed with the Nature of Mathematics items, agreed with the Doing, Validating, and Learning Mathematics items, and somewhat more than agreed with the Usefulness of Mathematics items. Therefore, the participants had moderately sophisticated mathematical beliefs. Based on the MTEBI subscale means, the participants agreed with the PMTE items, but somewhat less than agreed with the MTOE items, which indicated that they had moderately strong beliefs in their capabilities to teach mathematics effectively, even with their limited mathematics teaching experiences. Based on the Problems subscale mean, the participants had much confidence in their capabilities to solve the mathematics problems.

To test hypothesis 1, Pearson correlations were calculated among the six subscales, which are presented in Table 1. Using the Bonferroni adjustment to prevent inflation in the Type I error rate for multiple comparisons, the Bonferroni-adjusted alpha was set to .003. The correlations among the three mathematical belief subscales were all statistically significant ($p < .001$), with the strongest correlation ($r = .73$) between the Doing, Validating, and Learning Mathematics subscale and the Usefulness of Mathematics subscale. The correlation between the PMTE subscale and the MTOE subscale was not statistically significant, which supports the distinctiveness of the two dimensions of mathematics teaching efficacy. The PMTE subscale was statistically significantly related to all three mathematical belief subscales ($p < .001$), whereas the MTOE subscale only was statistically significantly related to the Doing, Validating, and Learning Mathematics subscale ($p = .001$). The Problems subscale was statistically significantly related to the three belief subscales ($p < .003$) and to the PMTE subscale ($p < .001$), but not to the MTOE subscale. In addition, the correlation between a composite score of the three mathematical belief subscales of the CMI-R and a composite score of the two subscales of the MTEBI was statistically significant ($r = .69$, $p < .001$), as well as the correlation between the CMI-R composite score and the MSES-R Problems subscale ($r = .48$, $p < .001$). The correlation between the MTEBI composite score and the MSES-R Problems subscale also was statistically significant ($r = .48$, $p < .001$).

To test hypothesis 2, simultaneous multiple regression analyses were conducted using SPSS 17.0. All assumptions pertaining to normality, linearity, and homoscedasticity were met. For the prediction of mathematics teaching efficacy, the first model contained the CMI-R composite score and the MSES-R Problems subscale as the independent variables and the MTEBI composite score as the dependent variable. This model was statistically significant, $R^2 = .507$, Adj. $R^2 = .496$, $F(2, 92) = 47.29$, $p < .001$, which explained approximately 51% of the variance in the scores of the MTEBI. Both the composite mathematical beliefs score, $B = 0.26$, $SE = 0.04$, $t(94) = 7.24$, $p < .001$, and the Problems subscale, $B = 0.25$, $SE = 0.11$, $t(94) = 2.27$, $p < .05$, were statistically significant predictors of the MTEBI scores, with the composite mathematical beliefs score as the stronger predictor. A second model containing the three mathematical belief subscales and the MSES-R Problems subscale also was statistically significant, $R^2 = .575$, Adj. $R^2 = .556$, $F(4, 90) = 30.47$, $p < .001$, which accounted for 58% of the variance in the MTEBI scores. Of the four measures, two were statistically significant predictors of the scores of the MTEBI. The Doing, Validating, and Learning Mathematics subscale, $B = 0.53$, $SE = 0.11$, $t(94) = 4.93$, $p < .001$ was a stronger predictor than the Usefulness of Mathematics subscale, $B = 0.35$, $SE = 0.17$, $t(94) = 2.01$, $p < .05$. The Problems subscale was no longer statistically significant.

To test hypotheses 3a and 3b, the participants were divided into three groups based on their composite mathematical beliefs scores. The composite mathematical beliefs scores were equally distributed, so 32 pre-service teachers were placed into the low level of sophistication group, 32 pre-service teachers were placed into the moderate level of sophistication group, and 31 pre-service teachers were placed into the high level of sophistication group. For hypothesis 3a, the three levels of mathematical beliefs were used as the between subjects factors in a one-way analysis of variance (ANOVA) with the MTEBI composite score as the dependent variable. A test of homogeneity of variance revealed no statistically significant effect, $F(2, 92) = .14$, $p > .05$, which indicated that the variances in the three groups did not differ significantly. The ANOVA revealed a statistically significant difference in mathematics teaching efficacy among the low ($M = 77.09$, $SD = 7.12$), moderate ($M = 83.84$, $SD = 5.47$), and high ($M = 89.52$, $SD = 5.92$) levels, $F(2, 92) = 31.61$, $p < .001$, $\eta_p^2 = .41$. The Bonferroni post hoc analysis revealed that the high level scored statistically significantly higher than the moderate level (p = .001) and than the low level (p < .001). In addition, the moderate level scored statistically significantly higher than the low level (p < .001).

For hypothesis 3b, the three levels of mathematical beliefs were used as the between subjects factors in a one-way ANOVA with the MSES-R Problems subscale as the dependent variable. A test of homogeneity of variance revealed no statistically significant effect, $F(2, 92) = 2.00$, p > .05. The ANOVA revealed a statistically significant difference in mathematics self-efficacy among the low (M = 49.69, SD = 6.32), moderate (M = 54.12, SD = 6.23), and high (M = 55.00, SD = 4.37) levels, $F(2, 92) = 7.86$, p = .001, $\eta_p^2 = .15$. The Bonferroni post hoc analysis revealed that the low level scored statistically significantly lower than the moderate level (p < .01) and than the high level (p = .001). There was no statistically significant difference between the moderate level and the high level.

Discussion

The present study examined the relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for elementary pre-service teachers. For the participating pre-service teachers, personal mathematics teaching efficacy was found to have a statistically significant positive relationship to the belief about the nature of mathematics, to the belief about doing, validating, and learning mathematics, and to the belief about the usefulness of mathematics. The pre-service teachers who reported stronger beliefs in their capabilities to teach mathematics effectively were more likely to possess more sophisticated mathematical beliefs. These results support other research findings (Esterly, 2003; Swars et al., 2007). Personal mathematics teaching efficacy also was found to have a statistically significant positive relationship to mathematics self-efficacy, which also supports previous findings (Bates et al., 2011). The pre-service teachers who reported stronger beliefs in their capabilities to teach mathematics effectively were more likely to have more confidence in solving mathematics problems. However, mathematics teaching outcome expectancy only was statistically significantly positively related to the belief about doing, validating, and learning mathematics. The pre-service teachers who believed that effective mathematics teaching can produce student learning were more likely to believe that learning mathematics involves understanding and sense making. Yet, this result might be due to the inadequate reliability of the scores of the MTOE subscale. Mathematics self-efficacy was found to have a statistically significant positive relationship with the three mathematical beliefs. Pre-service teachers who reported more confidence in solving mathematics problems were more likely to have more sophisticated mathematical beliefs. These results are consistent with previous research (Esterly, 2003). Altogether, these findings corroborate that all three constructs were positively related for the pre-service teachers.

Both mathematical beliefs and mathematics self-efficacy were statistically significant positive predictors of mathematics teaching efficacy, which explained 51% of the variance in mathematics teaching efficacy. Using Cohen’s (1988) criteria, the effect size was large. This result is somewhat contrary to previous research, in which mathematics self-efficacy was not a statistically significant predictor of mathematics teaching efficacy (Esterly, 2003). Even though different instruments were used in the present study, another possible explanation is that the MSES-R Problems subscale contained items relating to upper elementary mathematical concepts and the mathematics content course in which the participants were enrolled emphasized upper elementary mathematical concepts: Thus, the pre-service teachers were more confident in solving the mathematics problems and were more apt to believe that they could teach that level of mathematics effectively. However, for the three individual mathematical belief subscales along with mathematics self-efficacy, only the belief about doing, validating, and learning mathematics and the belief about the usefulness of mathematics were statistically significant positive predictors of mathematics teaching efficacy, which explained 58% of the variance in mathematics teaching efficacy. The effect size was large, using Cohen's (1988) criteria. Yet, mathematics self-efficacy was no longer a statistically significant predictor, which is consistent with previous findings (Esterly, 2003). Therefore, the role of mathematics self-efficacy in the prediction of mathematics teaching efficacy remains ambiguous.

Mathematical beliefs were found to have a statistically significant effect on mathematics teaching efficacy. The effect size ($\eta_p^2 = .41$) was large, using Cohen's (1988) criteria. There were statistically significant differences between the low and the moderate levels, between the low and the high levels, and between the moderate and the high levels of sophistication of beliefs. Pre-service teachers with more sophisticated mathematical beliefs reported greater efficacy for teaching mathematics, whereas pre-service teachers with less sophisticated beliefs reported less efficacy for teaching mathematics. These findings support previous research (Esterly, 2003) and suggest that mathematical beliefs play an important role in the mathematics teaching efficacy of the pre-service teachers.

Mathematical beliefs also were found to have a statistically significant effect on mathematics self-efficacy. Using Cohen's (1988) criteria, the effect size ($\eta_p^2 = .15$) was large. There were statistically significant differences between the low and the moderate levels and between the low and the high levels of sophistication of beliefs. Pre-service teachers who had more sophisticated mathematical beliefs reported more confidence to solve mathematics problems, whereas pre-service teachers who had less sophisticated mathematical beliefs reported less confidence to solve mathematics problems. This result is contrary to previous research, in which mathematical beliefs did not have a statistically significant effect on mathematics self-efficacy (Esterly, 2003). Possible explanations for this finding are the use of different instruments to measure both mathematical beliefs and mathematics self-efficacy or the different samples that were selected. These findings suggest that mathematical beliefs also play a role in the mathematics self-efficacy of the pre-service teachers.

Implications

One quality that an elementary pre-service teacher should possess is mathematics teaching efficacy, which is a belief in his or her capability to teach mathematics effectively. Researchers have shown that the mathematics teaching efficacy of elementary pre-service teachers can increase during coursework in a teacher education program (e.g. Swars et al., 2007). The results of the present study have shown that mathematical beliefs were a statistically significant predictor of and had a statistically significant effect on mathematics teaching efficacy, which provide more support for the importance of the mathematical beliefs of pre-service teachers as well. Although pre-service teachers enter a teacher education program with established mathematical beliefs, researchers have shown that pre-service teachers' beliefs can be influenced by teacher education programs (Beswick, 2006; Gill et al., 2004; Swars et al., 2007; Wilkins & Brand, 2004). Yet, for change possibly to occur, pre-service teachers must reflect on their beliefs (Philipp, 2007). If beliefs are established through classroom experiences (De Corte et al., 2002), then pre-service teachers' naïve mathematical beliefs might be recognized, challenged, and reflected upon in the classroom environment. Changes in mathematical beliefs have been evidenced in methods courses that incorporated constructivist principles (Hart, 2002; Steele & Widman, 1997; Swars et al., 2007; Wilkins & Brand, 2004). Likewise, mathematics content courses for elementary pre-service teachers also should be taught in a more constructivist manner in order for the pre-service teachers possibly to develop beliefs that are consistent with the reform ideals of the NCTM *Principles and Standards* (Hart, 2002; Swars et al., 2007). Pre-service teachers' reflections on their mathematical beliefs in a constructivist classroom might bring about more lasting change to their mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy, which might continue on into their teaching careers.

However, limitations to these findings exist. One limitation is the small sample size. Thus, the results should be interpreted with caution. In addition, the mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy of this convenience sample of pre-service teachers might not be representative of pre-service teachers as a whole. Generalizations cannot be made to other institutions that are not comparable to the southeastern regional university from which the sample was chosen.

For future research, a qualitative study might yield rich descriptions of the relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs. Furthermore, a study that included, along with the other three constructs, a measure of pre-service teachers' performance on successfully solving these particular mathematics problems might be worthwhile. Even though the present study's findings provide evidence for positive relationships among the three constructs, further research is needed in order to comprehend further the complexities among mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy for elementary pre-service teachers.

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