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Perceptions of Elementary Pre-service Teachers' Confidence to Teach Mathematics

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Perceptions of Elementary Pre-service Teachers' Confidence to Teach Mathematics

Abstract

In this study, we examine the perceptions of pre-service teachers' confidence to teach mathematics. Previous studies have focused on the relationship between mathematics anxiety and teacher efficacy, mathematics anxiety and content knowledge, or teacher efficacy and content knowledge. In order for educational researchers to understand the dynamics of teaching mathematics with confidence, we examine the relationships among all three constructs: mathematics anxiety, teacher efficacy, and content knowledge. Two well-known instruments, Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) and the short version of Mathematics Anxiety Rating Scale (MARS-S), were completed by 117 elementary pre-service teachers at a state college. Along with these instruments, pre-service teachers' Content Specialty Test in Mathematics (CST-Math) scores from the New York State Teacher Certification Examinations were used as the measurement for their overall content knowledge. Our results indicated that there were significant correlations between each pair of the three constructs. While teacher efficacy remained significantly correlated with mathematics anxiety and with content knowledge when holding the third construct constant, there was no significant correlation shown between mathematics anxiety and content knowledge when holding teacher efficacy constant.

Keywords: math anxiety, teaching efficacy, math content knowledge

The purpose of the National Council of Teachers of Mathematics (NCTM) is to provide students with best mathematics education possible (NCTM, 2000). Mathematics anxiety studies

of elementary preservice teachers have been numerous. At the same time, there are various studies that discuss the effect of mathematics anxiety on teacher efficacy. Since efficacy is content specific, highly anxious preservice mathematics teachers not only try to avoid mathematics, but also demonstrate low teacher efficacy. In the past few decades, most research on teacher quality has focused on content knowledge (Ball, Hill, & Bass, 2005; Kahan, Cooper, & Bethea, 2003; Ma, 1999). It is accepted that the best teachers are those who know their content area very well. Previous studies have focused on the relationship between mathematics anxiety and teacher efficacy, mathematics anxiety and content knowledge, or teacher efficacy and content knowledge. In order for educational researchers to understand the dynamics of teaching mathematics with confidence, it is important to look at the relationships among all three constructs: mathematics anxiety, teacher efficacy, and content knowledge. In this study we focus on the relationship among all three constructs.

Mathematics anxious people have high mathematics anxiety and tend to avoid it. In the long term, they limit their career opportunities due to a lack of mathematics background (Betz, 1978; Dew, Galazzi, & Galassi, 1983). The National Council of Teachers of Mathematics (NCTM) states that “those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures” (NCTM, 2000, p. 5). There are limited career options for people who struggle with mathematics (Betz, 1978; Dew, Galassi, & Galassi, 1983).

Mathematics anxiety is defined as a state of discomfort when an individual is required to perform a mathematical task (Wood, 1988; Trujillo & Hadfield, 1999; Vinson, 2001), or to “experience feelings of tension, apprehension, or mental disorganization an individual has when

required to manipulating numbers and shapes” (Richardson & Suinn, 1972; Tobias, 1978). Mathematics anxiety also causes low self-esteem, helplessness, mental disorganization, stress, and worry (Hart, 2002; Wigfield & Meece, 1988). Mathematics anxiety can be very serious and may result in the avoidance of mathematics altogether for some. Others may even develop a phobia for mathematics (Tobias, 1978).

Consequently, mathematics anxiety has repercussions on a teacher’s practices in mathematics (Bush, 1981; Hembree, 1990; Vinson, 2001). Those teachers who have high mathematics anxiety tend to use more traditional teaching methods, such as direct instruction, teaching the textbook problem by problem, rote memorization, and focus on basic skills rather than concepts in mathematics. These teachers spend less time on problem solving, small-group instruction, and individualized instruction. Further, Karp (1991) found that elementary teachers with poor attitudes toward mathematics engaged in teaching methods that fostered dependency among students, with teacher as the main source of information. Moreover, teachers with high mathematics anxiety avoid teaching mathematics altogether (Trice & Ogden, 1986), and may perpetuate their negative attitude toward mathematics among their students (Bush, 1989; Ma, 1999; Sovchik, 1996; Swetman, 1994; Trice & Ogden, 1986).

In response to the prevalence of mathematics anxiety among preservice teachers and its effect on mathematics teacher effectiveness, researchers have investigated the relationship between mathematics anxiety and other constructs. Even though there are studies concerning only mathematics anxiety in preservice teachers and separate studies concerning teacher efficacy, there are limited studies that provide coherent explanations for mathematics anxiety and teacher efficacy in mathematics together. However, there is a lack of research on the teacher confidence in terms of the three aforementioned constructs to teaching mathematics. Research on teachers’

efficacy is mostly linked with classroom instructional strategies, willingness to embrace educational reform, commitment to teaching, and student achievement (Swars, Daane, & Giesen, 2006). Teacher efficacy is derived from the theory of self-efficacy (Bandura, 1994, 1997). Bandura's theoretical framework of self-efficacy has two dimensions: efficacy expectations and outcome expectations. To produce the desired outcome, an individual's conviction that they can successfully execute the necessary behavior is described as efficacy expectation. The individual's estimate that the given behavior will lead to certain outcome is termed as outcome expectations (Swars, Daane, & Giesen, 2006).

Consistent with Bandura's framework, many researchers consider teacher efficacy to be a two-dimensional construct (Ashton, 1985; Dembo & Gibson, 1985; Enochs, Smith, & Huinker, 2000). The first factor is the personal teaching efficacy, which represents a teachers' belief in his or her skill to be an effective teacher. The second factor, teaching outcome expectancy, is the teachers' belief that they can bring about student learning regardless of external factors such as home environment, family background, and parental influences. Teacher self-efficacy is of particular interest because, once "efficacy beliefs are established they appear to be somewhat resistant to change" (Hoy & Spero, 2005). Early in learning is when self-efficacy beliefs are most adaptable; hence the first few years of teacher development could be critical to the long-term development of teacher efficacy (Hoy, 2004). Further, teachers with a high sense of teacher efficacy work harder and persist longer, which in turn, influences student learning while those with a low sense of teacher efficacy are more likely to use teacher-directed strategies such as lecture and reading from the text (Czernaik, 1990; Smith 1996; Woolfolk Hoy, Hoy, & Davis, 2009). Teacher efficacy has been correlated with significant variables such as classroom instructional strategies and willingness to embrace innovations (Woolfolk Hoy, Hoy, & Davis,

2009). Czernaik (1990) reports that teachers with high sense of self-efficacy use a variety of instructional strategies such as inquiry based instruction and student-centered instructional strategies. These teachers are willing to use manipulatives, try and implement new strategies, and share control of the classroom with their students (Czerniak & Schriver, 1994; Swars, Hart, Smith, Smith, & Tolar, 2007; Woolfolk Hoy, Hoy, & Davis, 2009). Whereas, teachers with low sense of self-efficacy are more likely to use teacher-directed strategies, such as, lecture, reading from the text, and very little problem-solving strategies in the classroom.

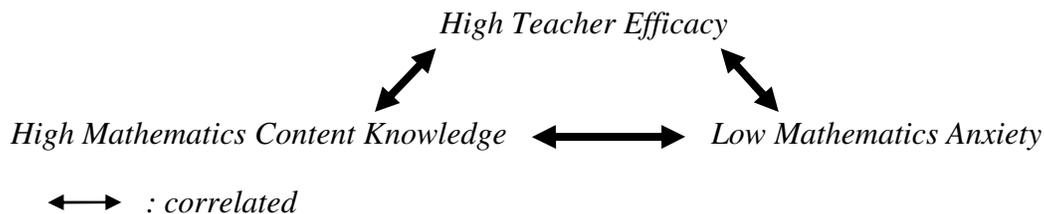
Furthermore, efficacy beliefs are situational. Efficacy beliefs depend on the context or situation relative to the action or task to be performed, and they are not generalized expectancy (Bandura 1997; Pajares, 1996; Woolfolk, 2010; Wilson & Trainin, 2007). It is therefore important to study teacher efficacy beliefs within a specific content area, such as mathematics. Most research on mathematics teaching efficacy and preservice teachers have examined the effects of a mathematics methods course. Elementary preservice teachers' participation in a mathematics methods course corresponded to a significant increase in teaching efficacy (Cakiroglu, 2000; Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005). Because a teacher's sense of efficacy is dependent on content knowledge; researchers have chosen to address mathematics content knowledge with teacher perception of self-efficacy (Newton, Leonard, Evans, & Eastburn, 2012; Swars, Daane, & Giesen, 2006; Swars, Hart, Smith, Smith, & Tolar, 2007). Ball, Hill, and Bass (2005) emphasize the importance of specialized content knowledge needed for teaching elementary mathematics. In preservice elementary education teachers who have completed a mathematics methods course, Newton et al (2012) found a positive moderate relationship between mathematics content knowledge and perceptions of self-efficacy. Further, Swars et al (2006) reported that lower mathematics anxiety was related to

higher perceptions of self-efficacy. Additionally, Swars et al (2007) found an increase in teacher self-efficacy over the course of an elementary mathematics methods class.

Several mathematics educators have agreed that there is a need for elementary teachers to possess strong content knowledge.. A few mathematicians and many mathematics educators have proposed that there is a need for specialized content knowledge to teach elementary mathematics that is quite different from the knowledge of general mathematics necessary to perform basic math functions as an adult in society (Ball, Hill, & Bass, 2005). It is interesting to note that there is a lack of research on the relationship between mathematics anxiety and mathematics content knowledge.

In this study, we focus on the relationship between math anxiety, teacher efficacy, and content knowledge, which we term as *confidence to teach*. While there are researchers that examine the relationship between mathematics anxiety and teacher efficacy, very little research has been done on mathematics anxiety and content knowledge, and mathematics efficacy and content knowledge. What researchers have failed to study is the interrelationship among all the three constructs. The diagram below shows the proposed relationship among the three constructs. For example, in order to have confidence to teach mathematics, preservice teachers must possess low mathematics anxiety, high content knowledge in mathematics, and high teacher efficacy. Similarly, high mathematics anxiety may result in low teacher efficacy and low content knowledge. Conversely, preservice teachers with low mathematics anxiety may claim to possess high teacher efficacy and high content knowledge.

Diagram 1



The purpose of this study was to investigate the following research question: What is the relationship among mathematics anxiety, teacher self-efficacy, and mathematics content knowledge among elementary preservice teachers?

Method

Subjects

This study included elementary preservice teachers who enrolled in the one semester of three-credit elementary mathematics methods course at a four-year Master's comprehensive public institution located in New York State. In this study, there were a total of 117 preservice teachers including 103 females and 14 males.

Measure Instruments

The main instruments used in this study were the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Enochs et al., 2000), and a short version of Mathematics Anxiety Rating Scale (MARS-S) (Suinn & Winston, 2003). The MTEBI was designed to measure the level of mathematics teaching efficacy of the respondents. It consists of 21 Likert scaled items, scoring from 1 (strongly disagree) to 5 (strongly agree), and covers the two subscales of teacher efficacy: 13 items on the self mathematics teaching efficacy (MTEBI-SE) and eight items on the mathematics teaching outcome expectancy (MTEBI-OE). The total and mean scores for MTEBI-SE and MTEBI-OE were calculated separately and their combined total score were the

MTEBI score. The short version of MARS-S used in the study had 30 items that provided comparable reliability and validity to the original 98-item MARS version (Suinn & Winston, 2003). A high score on MTEBI indicates a high level of teaching efficacy and a high MARS or MARS-S score indicates high anxiety towards mathematics.

In addition to these instruments, preservice teacher's score obtained on the Content Specialty Test in Math (CST-Math) from the New York State Teacher Certification Examinations was used as the measure for their overall content knowledge. The CST-Math scores range from 100 to 300 and a test-taker needs a minimum score of 220 to pass the test. In the study, MTEBI and MARS-S were administered in class and the CST examination was taken by the pre-service teachers at their own discretion.

Results

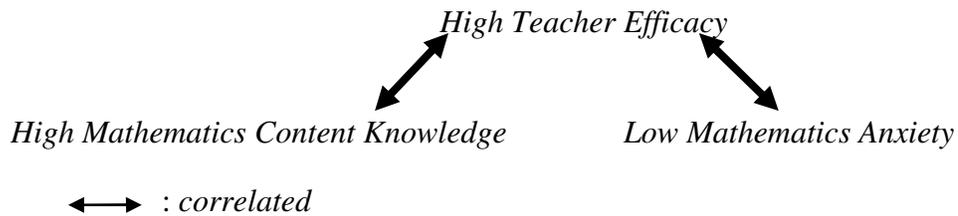
The Cronbach's alpha is 0.77 for MTEBI and 0.93 for MARS-S, showing that both instruments have very good reliability for the group of sample. MTEBI has a mean score of 76.9 and standard deviation (s.d.) 7.5, while MARS-S has a mean score 67.2 and s.d. 17.7. The CST-Math score has a mean 272.4 and s.d. 21.7.

Table 1 shows the zero-order correlations between content knowledge, teacher efficacy, and mathematics anxiety. It is shown that CST-Math score has a significant positive correlation with the overall MTEBI but a negative correlation with MARS-S. CST-Math score also has significant positive correlation with the subscale MTEBI-SE but not with the subscale MTEBI-OE. This indicates that preservice teachers who have greater content knowledge tend to have higher self teaching efficacy but not necessarily believe in the outcome expectancy. Moreover, MARS-S was found negatively correlated with MTEBI and MTEBI-SE but not with MTEBI-OE. Therefore, we can conclude that preservice teachers who have greater content knowledge or

have lower mathematics anxiety tend to have higher self teaching efficacy, but not necessarily have any correlation with outcome expectancy efficacy.

Furthermore, we examined the correlations by using partial correlations between two of the variables while holding the third variable constant. The partial correlations show that MTEBI remains negatively correlated with MARS-S ($r = -.505, p < .001$) when holding the CST-Math constant, while it remains positively correlated with CST-Math ($r = .195, p < .05$) when holding MARS-S constant. However, no significant linear correlation was found between MARS-S and CST-Math while holding MTEBI constant ($r = -.083, p > .30$), which deviates from the aforementioned significant negative zero order correlation between MARS-S and CST-Math. The partial correlations are shown as in Diagram 2.

Diagram 2



Discussion

This study examined three constructs during an elementary teacher preparation program: mathematics anxiety, teacher efficacy, and content knowledge. From our analysis we found that elementary preservice teachers who have high teaching efficacy tend to have low mathematics anxiety and also have high mathematics content knowledge. This result is consistent with the findings from other studies.

Our study also reveals that those who have low mathematics anxiety tend to have high mathematics content knowledge. However, while teacher efficacy was held constant, their

correlation becomes insignificant. This indicates that the relationship between low mathematics anxiety and high mathematics content knowledge may be because of their high teacher efficacy (Ernest, 1989). This can also be explained by Swars et al. (2007):

What is interesting in these results is the disconnect between pre-service teachers' specialized content knowledge and their belief in skills and abilities to teach mathematics effectively. It appears that preservice teachers can be quite efficacious about their teaching and have developed strong specialized content knowledge for teaching mathematics. This naive perspective is not surprising and is consistent with the human condition of not being aware of what you do not know. (p. 333).

It is intuitive to think that high content knowledge would result in low mathematics anxiety. However, there is a lack of research to understand the dynamics between mathematics anxiety and content knowledge. More studies are required to investigate content knowledge of elementary preservice teachers. In mathematics methods courses, the assumption is that preservice teachers possess adequate content knowledge so the course mainly emphasizes pedagogy. Swars et al. (2007) found an increase in teacher efficacy over an elementary mathematics methods class.

Efficacy appears to be the common factor of the three constructs we discussed in this study, therefore we cautiously conclude that preservice teachers' perception of their confidence to teach mathematics seems to be embedded mostly in their teacher efficacy and less in mathematics anxiety and content knowledge.

Table 1

Correlations between content knowledge, teacher efficacy, and mathematics anxiety

		MARS-S	MTEBI	MTEBI-SE	MTEBI-OE
CST-Math	Pearson Correlation	-.214*	.275**	.245**	.130
MARS-S	Pearson Correlation		-.533**	-.594**	-.023
MTEBI	Pearson Correlation			.892**	.475**
MTEBI-SE	Pearson Correlation				.026

Note: *p < 0.05. **p < 0.01. CST-Math: Content Specialty Test score in Math, MARS-S: Mathematics Anxiety Rating Scale short version, MTEBI: Mathematics Teaching Efficacy Beliefs Instrument, SE: self teaching efficacy, OE: teaching outcome expectancy, N=117.

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