Mathematics Self-Efficacy and Content Knowledge:
Exploring the Connection for Elementary Preservice Teachers

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Abstract

Data on content knowledge and self-efficacy beliefs were collected from 41 elementary preservice teachers enrolled in a mathematics methods course. Correlational analysis was used to determine whether a relationship existed between elementary preservice teachers' mathematics content knowledge (MCK) and two factors representing mathematics teacher self-efficacy, Mathematics Teaching Outcome Expectancy (MTOE) and Personal Mathematics Teaching Efficacy (PMTE; Enochs, Smith, & Huinker, 2000). MCK was measured using the Praxis® Elementary Education: Multiple Subjects: Mathematics. No statistically significant relationship was found between preservice teachers' MTOE and MCK, nor between PMTE and MCK. These findings are similar to those of Newton, Leonard, Evans, and Eastburn (2012) whose results suggested elementary preservice teachers' prior experiences with learning mathematics content may become less important in terms of efficacy judgments as they gain positive experiences with teaching mathematics. Implications for practice and future research will be discussed.

Keywords: elementary mathematics, content knowledge, teacher self-efficacy, preservice teachers

Introduction

For years, teachers' content knowledge has been recognized as an important and necessary instructional attribute (Shulman, 1986), and since passage of the No Child Left Behind Act (NCLB; 2002), the definition of a highly-qualified teacher has been linked to content knowledge in federal legislation. Not surprisingly, there has been a substantial increase in the number of published research articles on preservice teachers' mathematical content knowledge (MCK) over the past few decades (Thanheiser, et al., 2014). Similarly, teachers' self-efficacy beliefs, how capable teachers believe themselves to be to deliver instruction to students, have been a focus of research since the late 1970's and has been on the increase in recent years (Armor et al., 1976; Dembo & Gibson, 1985; Klassen, Tze, Betts, & Gordon, 2011; Tschannen-Moran & Woolfolk Hoy, 2001; Zee & Koomen, 2016). Past research provides evidence that teachers who report more positive self-efficacy beliefs exhibit various desirable teaching behaviors including: delivering process-oriented instruction, establishing appropriate learning goals for students and revising those goals frequently based on student performance, and employing effective teaching strategies including differentiated instruction to support inclusion of students with diverse learning needs (Allinder, 1995; Martin, Sass, & Schmitt, 2012; Thoonen, Sleegers, Oort, Peetsma, & Geijsel, 2011; Wertheim & Leyser, 2002; Weshah, 2012). Furthermore, teachers' self-efficacy beliefs have been linked, in some cases, to students' academic achievement, motivation, and self-efficacy (Midgley, Feldlaufer, & Eccles, 1989; Ross, 1992; Thoonen, Sleegers, Peetsma, & Oort, 2011).

When considering research specific to teaching mathematics, there is some evidence that teachers with high self-efficacy are more successful in developing students' proficiency with mathematical skills than teachers with low self-efficacy (Allinder, 1995; Hines, 2008; Midgley et al., 1989; Throndsen & Thurno, 2013). Unfortunately, many preservice elementary teachers participating in mathematics teaching methods courses enter with low self-efficacy beliefs regarding teaching mathematics and inadequate understanding of mathematical concepts (Ball, 1990; Bursal & Paznokas, 2006; Huinker & Madison, 1997: Ma, 1999). Some evidence suggests that lower levels of teaching efficacy in mathematics may be due, in part, to inadequate preparation in mathematics and low mathematical understanding and performance (Bates, Latham, & Kim, 2011; Phelps, 2010; Thomson, DiFrancesca, Carrier, & Lee, 2017). While content knowledge and self-efficacy are important indicators of instructional performance, they are also attributes that can be developed in preservice teachers (Charalambous et al., 2008; Cohrssen & Tayler, 2016; Palmer, 2006). Therefore, the possible relationship between preservice teachers' MCK and their self-efficacy for teaching mathematics is of particular importance to teacher educators. The purpose of the current study was to investigate the relationship between elementary preservice teachers' MCK and two factors representing mathematics teacher self-efficacy, Mathematics Teaching Outcome Expectancy (MTOE) and Personal Mathematics Teaching Efficacy (PMTE; Enochs, et al., 2000).

Methodology

Participants

This study was conducted at a large research university situated in an urban city in the southeastern United States. The university is classified by the Southern Association of Colleges and Schools as a Level VI institution and by the Carnegie Foundation for the Advancement of Teaching as Doctoral/Research Intensive University. The College of Education where the participants were enrolled consists of approximately 1,750 undergraduate and graduate students, and the participants' program (K-6 Teacher Education) is the largest in the college.

Participants were 41 preservice teachers seeking a Class B teaching certificate in both Elementary Education and Collaborative Teaching (K-6). Participant demographics were typical of this program; all participants were female, seniors and predominantly Caucasian (32 Caucasian and 9 African American).

Instruments

Instruments included the Praxis® Elementary Education: Multiple Subjects: Mathematics subtest (Test Code 5033) and the Mathematics Teaching Efficacy Beliefs Instrument (Enochs et al., 2000). The Elementary Education: Multiple Subjects test is designed to assess whether a candidate has the broad knowledge and competencies necessary to be licensed as a beginning teacher at the elementary school level (Educational Testing Services, 2012), and is part of the licensing procedure in many states. The Mathematics subtest contains 40 selected-response questions (26 Numbers, Operations, and Algebraic Thinking items; 14 Geometry, Measurement, Data, and Interpretation) typically covered in a bachelor's degree program in elementary education. A minimum score of 157 on the Mathematics subtest is required before participants begin their student teaching semester.

The second instrument was the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). The MTEBI was created by Enochs, et al. (2000) who modified the Science Teaching Efficacy Belief Instrument (STEBI; Enochs & Riggs, 1990) to create an instrument that could measure the mathematics teaching efficacy beliefs of preservice teachers. Both the STEBI and the MTEBI rely on Gibson and Dembo's (1984) Teacher Efficacy Scale (TES) which operationally defines teacher self-efficacy as a construct made up of two factors: personal teaching efficacy and general teaching efficacy.

> Personal teaching efficacy: "belief that one has the skills and abilities to bring about student learning." (p. 573)
>
> General teaching efficacy: "belief that any teacher's ability to bring about change is significantly limited by factors external to the teacher, such as the home environment, family background, and parental influences." (p. 574)

Gibson and Dembo (1984) linked personal teaching efficacy with Bandura's (1977) conception of self-efficacy beliefs: an individual's beliefs about his or her own ability to perform specific behaviors. The general teaching efficacy factor was linked with Bandura's (1986) conception of outcome expectancy, defined as an individual's judgment of the likely consequences of his or her actions. Based on their interpretation of

Bandura's (1977) theory of social learning, Gibson and Dembo (1984) posited that ". . . teachers who believe student learning can be influenced by effective teaching (outcomes expectancy beliefs) and who also have confidence in their own teaching abilities (self-efficacy beliefs) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback than teachers who have lower expectations concerning their ability to influence student learning (p. 570)."

However, Gibson and Dembo's (1984) two-factor teacher self-efficacy construct has been called into question based on both psychometric and theoretical difficulties (Henson, 2002; Tschannen-Moran & Woolfolk Hoy, 2001). The most notable critics may have been Tschannen-Moran and Woolfolk Hoy (2001) who developed the Teacher Sense of Efficacy Scale (TSES) to measure teacher self-efficacy in a way they claimed more closely represented Bandura's (1986, 1997, 2001) theoretical framework. The TSES was developed to measure teacher self-efficacy across three factors (Instruction, Classroom Management, and Student Engagement) using items restricted to teachers' beliefs about their own capabilities and did not include items regarding the potential impact that teachers in general are able to have on students despite external challenges (outcome expectancy). Tschannen-Moran and Woolfolk Hoy (2001) also pointed to low internal consistency reliability for the general teaching efficacy factor of Gibson and Dembos's (1984) scale, along with issues of item cross-loading found by other researchers (e.g., Coladarci & Fink, 1995; Guskey & Passaro, 1994; Henson, 2002; Woolfolk & Hoy, 1990).

However, while the three-factor structure of Tschannen-Moran and Woolfolk Hoy's (2001) TSES has produced strong evidence as a sound measure for inservice teachers, data gathered from preservice teachers has not supported the proposed three factor structure (Duffin, French, & Patrick, 2012; Fives & Buehl, 2009; Tschannen-Moran & Woolfolk Hoy, 2001). Therefore, for the current study, which is focused specifically on the mathematics self-efficacy beliefs of preservice teachers, the MTEBI was employed. The MTEBI was developed and validated specifically for preservice teachers and remains a widely used instrument for measuring the efficacy beliefs of preservice teachers (Bates, Latham, & Kim, 2011; Bursal & Paznokas, 2006; Moody & DuCloux, 2015; Swars, Daane, & Giesen, 2006; Thompson et al., 2017).

The 21-item MTEBI uses a five-point, forced-choice response Likert-type scale ranging from "Strongly Agree" to "Strongly Disagree" to obtain individual's perceptions of mathematics teaching efficacy beliefs on each of the two subscales--Personal Mathematics Teaching Efficacy (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE). A response of "Strongly Agree" indicates the highest level (5) of perceived efficacy whereas "Strongly Disagree" indicates the lowest level (1). The PMTE subscale consists of 13 items (2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, and 21) intended to elicit the preservice teachers' level of confidence in their own skills and abilities to teach mathematics, and included varied statements, such as ''I understand mathematics concepts well enough to be effective in teaching elementary mathematics.'' and ''I will find it difficult to use manipulatives to explain to students why mathematics works.'' The MTOE subscale consists of 8 items (1, 4, 7, 9, 10, 12, 13, and 14) intended to elicit the preservice teachers' beliefs regarding whether students' mathematics learning can be impacted by effective teaching, and included varied statements, such as ''When a student does better than usual in mathematics, itis often because the teacher exerted a little extra effort.'' and ''The inadequacy of a student's mathematics background can be overcome by good teaching.'' Eight negatively worded items (3, 6, 8, 15, 17, 18, 19 and 21) across both subscales were reverse coded so that scores corresponded with positively worded items.

Results

Data Collection and Analysis

The MTEBI was disseminated to a convenience sample of 41 preservice teachers enrolled in an elementary mathematics methods course during the last week of their semester, immediately prior to their student teaching semester. Missing data from seven participants resulted in listwise deletion so that only 34 responses were included in the correlational analysis. Visual analysis of histograms revealed no violation of univariate normality for any of the three variables (MCK, MTOE, and PMTE).

Two Cronbach's alpha coefficients were computed to assess the internal consistency reliability of items in each subscale (MTOE and PMTE). The alpha coefficient for items in the MTOE subscale was .679, and the alpha coefficient for items in the PMTE subscale was .765. The internal consistency reliability for items in the PMTE subscale was adequate (above .70; Tay & Jebb, 2017), while the internal consistency reliability for items in the MTOE subscale was nearly adequate.

The responses for the MTOE subscale (M = 3.6581, SD = .42) indicated that the preservice teachers agreed fairly strongly that students' mathematics learning can be impacted by effective teaching. Similarly, the responses for the PMTE subscale (M = 3.94, SD =.39), indicated that the preservice teachers strongly agreed that they had the skills and abilities to teach mathematics. The mean for the Praxis mathematics content knowledge score was 162.71, which was above the minimum score (157) required for the participants to show adequate MCK to begin their student teaching semester.

Bivariate correlations were computed to examine 1) the relationship between elementary preservice teachers' MCK and MTOE and 2) the relationship between elementary preservice teachers' MCK and PMTE. The relationship between the two self-efficacy factors (MTOE and PMTE) was also examined through correlational analysis. The bivariate correlations between MCK and both self-efficacy measures (MTOE and PMTE) were not statistically significant (results displayed in Table 1). Therefore, no evidence was obtained to suggest a relationship between preservice teachers' MCK and their self-efficacy beliefs. Additionally, the bivariate correlation between the two self-efficacy measures (MTOE and PMTE) was not statistically significant (results displayed in Table 1), indicating that preservice teachers with greater confidence in their own abilities to teach mathematics did not have greater confidence in the ability of effective teaching to impact students' mathematics learning.

Table 1

Bivariate Correlations

	Mathematics Content Knowledge (MCK)	Mathematics Teaching Outcome Expectancy (MTOE)	Personal Mathematics Teaching Efficacy (PMTE)
Mathematics Content Knowledge (MCK)	1	0.140	-0.034
Mathematics Teaching Outcome Expectancy (MTOE)		1	0.201
Personal Mathematics Teaching Efficacy (PMTE)			1

Note. *p< .05.

Discussion

Elementary preservice teachers in the current study conveyed high levels of efficacy regarding both their mathematics teaching abilities (PMTE) and the outcome expectancy (MTOE) for their students in mathematics. However, PMTE and MTOE were not significantly correlated indicating that preservice teachers that reported greater confidence in their own abilities did not necessarily also report greater outcome expectancy for their students. These results are similar to those of Briley (2012) who also found high levels of mathematics teaching efficacy and outcome expectancy among the 95 preservice teachers he surveyed using the MTEBI, but no significant correlation between the preservice teachers' confidence to teach math and their outcome expectancy for their students. While Bursal and Paznokas (2006) also found generally high levels of mathematics teaching efficacy and outcome expectancy among the 65 preservice teachers they surveyed using the MTEBI, about half of the preservice teachers who reported higher levels of math anxiety felt that they would not be able to teach mathematics effectively to their future students.

No statistically significant relationship was found between MCK and either of the self-efficacy subscales (MTOE and PMTE). These findings are similar to those of Newton et al. (2012) who found only a moderate positive relationship between content knowledge and personal teaching efficacy and no relationship between content knowledge and outcome expectancy. Newton et al. suggested that elementary preservice teachers' prior experiences with learning mathematics content may become less important in terms of efficacy judgments as they gain positive experiences with teaching mathematics. Therefore, it is recommended that future research follow preservice teachers into their student teaching placements to examine whether and how their mathematics teaching efficacy changes as they gain procedural and conceptual knowledge of the mathematics content taught in the elementary grades.

Implications for Research and Practice

Results of this study suggest that elementary preservice teachers' beliefs regarding their own ability to provide mathematics instruction to their students are not impacted by the amount of knowledge the preservice teachers have of mathematical content. Newton et al. (2012) pointed to preservice teachers' actual experiences instructing students in mathematics as a potentially more relevant source for increased self-efficacy beliefs. This assertion is in line with Bandura's (1997) social cognitive theory which identifies mastery experiences as the most impactful of the four sources of self-efficacy beliefs: mastery experiences, persuasion by a significant other, vicarious experiences, and physiological arousal. Bong and Skaalvik (2003) explained that it is not simply one's skill or ability level that determines self-efficacy, but rather what one can do with whatever skill or ability level one possesses that largely determines self-efficacy. Given the results of the current study, it would seem that more attention should be given to what preservice teachers "can do" with the mathematical content knowledge they have, rather than focusing on the mathematical content knowledge itself. Future research may consider elementary preservice teachers' pedagogical content knowledge for teaching mathematics, or elementary preservice teachers' ability to engage students in mathematics learning and manage student motivation. Based on the primary role actual experiences play in the development of self-efficacy, greater attention should be paid to the field-placement experiences that preservice teachers engage in, particularly in terms of mathematics instruction. Are preservice teachers being provided adequate opportunities to deliver mathematics instruction to students? Are preservice teachers being adequately supported so that they are set up for success in those mathematics teaching opportunities? Finally, are preservice teachers developing the necessary tools for student engagement and classroom management so that they can deliver mathematics instruction in the manner intended, and not have their efforts overwhelmed by the social and behavioral dynamics of a classroom or individual students? Mathematics self-efficacy, not only through effective coursework focused on reformed mathematics instruction and reflection (Briley, 2012), but also through structured and well-supported mathematics field experiences (Utley, Moseley, & Bryant, 2005).

Limitations

Use of a convenience sample of elementary preservice teachers from one university enrolled in a single semester was a limitation that reduced the generalizability of the findings. Another notable limitation is the small sample size, which possibly contributed to the non-significant findings in the current study. For future studies, it is recommended to include a larger number of participants from various institutions and/or over the course of several semesters.

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