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Preservice Teachers' Self-Efficacy for Teaching Mathematics

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Abstract: The perception of self-efficacy introduced by Albert Bandura's social cognitive theory is defined as a person's view of their capacity to organize and carry out the activities necessary for success in a specific situation. The most effective mathematics teachers believe that they are a capable and important influence on their students' understanding of mathematics, which is known as having a high self-efficacy for teaching mathematics. As efficacy for teaching is more difficult to change after the teacher enters the classroom, attending to preservice teachers' mathematics self-efficacy is worthy of examination within the teacher preparation program. The purpose of this study was to determine elementary and early childhood preservice teachers' self-efficacy beliefs related to teaching mathematics. Elementary and early childhood preservice teachers' (n = 203) mathematics teaching efficacy beliefs, including personal mathematics teaching efficacy and mathematics teaching outcome expectations, were measured at the beginning of the semester prior to internship. Responses indicated that participants had strong personal mathematics teaching efficacy but only modest expectations of their ability to positively influence students' mathematical learning. Implications for practice and future research are shared.

Introduction

The growing number of career opportunities that require advanced mathematical understanding make it essential that every child has elementary teachers confident in their abilities to teach mathematics effectively, which is known as mathematics teaching efficacy (Enochs et al., 2000). "Teachers' pedagogical beliefs and attitudes about what they can accomplish through their pedagogy influence their teaching actions and behaviors" (Alghamdi, 2023, p. 248). Teachers with strong self-efficacy for teaching mathematics are more likely to engage students in inquiry learning and other student-centered instructional practices (Lee et al., 2017; Swars et al., 2007). The immediate and long-term positive impact of strong mathematics teaching self-efficacy on student performance makes it a topic of significant interest and particular importance to teacher educators as teachers' self-efficacy beliefs have been linked to students' academic achievement, motivation, and self-efficacy (Chang, 2015; Lee at al., 2017). The purpose of this study was to examine elementary and early childhood preservice teachers' self-efficacy of teaching mathematics.

Purpose

The decision about what to put into your paragraphs begins with the germination of a seed of ideas; this "germination process" is better known as brainstorming. There are many techniques for brainstorming; whichever one you choose; this stage of paragraph development cannot be skipped. Building paragraphs can be like building a skyscraper: There must be a well-planned foundation that supports what you are building. Be sure to organize your paragraphs logically and consistently with this journal's guidelines by using this template. Cite all sources in accordance with APA (7th edition) for both in-text citations and in the references. Check to ensure that every source you have cited in-text is included in the references at the end of your paper. Also, check your paper for spelling and grammar before submitting it for peer review.

Review of the Literature

Teacher Efficacy

Self-efficacy beliefs are rooted in Bandura's social cognitive theory (1977), which defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). According to Bandura (1986), self-efficacy is influenced by four sources: performance accomplishments, vicarious experiences, verbal persuasion, and physiological states. The most influential source contributing to one's self-efficacy is personal accomplishments, which are derived from personal mastery experiences. The ability to successfully complete a challenging task – with little to no help from another – creates these master experiences leading to increased self-efficacy (Bandura, 1986). Also influencing one's self-efficacy are vicarious experiences, which involve observing another successfully completing a challenging task, resulting in an increase in one's confidence that they will also be successful in implementing the same task. Additional influences on one's self-efficacy are verbal persuasion by a believable and trustworthy source that one possesses the capabilities to master challenging situations or tasks and one's physiological state, which includes levels of stress and anxiety toward a task or behavior (Bandura, 1986).

Teacher efficacy refers to the beliefs a teacher possesses about their perceived overall teaching effectiveness and their ability to positively impact student learning (Knoblauch & Hoy, 2008; Lee et al., 2017; Tschannen-Moran & Hoy, 2001). Having examined the development of teacher efficacy beliefs, Tschannen-Moran et al. (1998) found that all four sources postulated by Bandura (1986) have been included in sources of teaching efficacy expectations, with the personal accomplishment achieved through mastery experiences being the prevailing source of teaching efficacy. Through actual classroom teaching, individuals gain insight into their ability to teach and can determine how their ability to manage, instruct, and evaluate students is influenced by their strengths and weaknesses. Observing others teach provides a vicarious experience that increases awareness regarding the nature of teaching tasks, including decisions about who is responsible for student learning and to what extent the teacher can make a difference in that learning. Verbal persuasion from supervisors or other teachers in the form of encouragement, strategies for meeting challenges, feedback on how to develop pedagogical skills, and/or advice for

implementing teaching tasks may also influence teacher efficacy by providing additional information about effective teaching. Lastly, the degree of emotional and physiological stimulation experienced in a particular teaching situation can affect one's self-perception of their teaching ability (Tschannen-Moran et al., 1998).

The importance of teachers' sense of efficacy has been well documented (e.g., Giles et al., 2016; Knoblauch & Hoy, 2008; Nie et al., 2013; Zee & Koomen, 2016). Teachers who report more positive self-efficacy beliefs exhibit such desirable teaching behaviors as delivering process-oriented instruction, trying new methods, developing students' interest in academic activities, persisting with students who struggle, establishing appropriate learning goals for students and revising those goals frequently based on student performance, and employing differentiated instruction to support inclusion of students with diverse learning needs (Barni et al., 2019; Nurlu, 2015; Perera & John, 2020). Further, teachers with a high sense of self-efficacy place more importance on building a warm relationship with their students (Nurlu, 2015) and have a greater sense of professional satisfaction as teachers (Klassen & Chiu, 2010) than their peers with lower perceptions of their ability to influence student learning.

Mathematics teaching efficacy, a domain-specific construct, is the belief in one's abilities to successfully execute mathematics teaching tasks (McMinn et al., 2021). Chang (2015) noted that the mathematics self-efficacy of fifth-grade teachers significantly influenced their students' mathematics self-efficacy and mathematical achievement, which was consistent with findings of previous studies linking teachers' mathematical self-efficacy to students' attitudes towards and abilities in mathematics (Zee & Koomen, 2016). Furthermore, elementary teachers' self-efficacy beliefs for teaching mathematics were positively associated with teachers' job satisfaction (Perera & John, 2020) and low anxiety levels (Ozben & Kilicoglu, 2021).

Elementary Preservice Teachers' Mathematics Efficacy

As teachers' efficacy predicts teacher practice and student outcomes, there is a need for teacher educators to devote extensive efforts to effectively facilitating preservice teachers' efficacy to teach mathematics to maximize their students' chances for success (Chang, 2015; Lee et al., 2017). McMinn et al. (2023) recommend that teacher educators take an active role in acknowledging and amending preservice teachers' mathematical beliefs during both content and methodology courses. Methods courses that offer opportunities for preservice elementary teachers who are mathematically anxious to acknowledge and address their anxieties while developing strategies to overcome their feelings may assist them in implementing effective teaching practices (Bosica, 2022; Lee et al., 2017). Additionally, methods courses taught in a constructivist manner were found to correspond to significant increases in mathematics teacher efficacy (Giles et al., 2016).

Since teaching experience may contribute to increased mathematics teaching efficacy (Takunyaci, 2021), mathematics methods courses that include field experiences may be particularly critical for the development of preservice teachers' teacher efficacy through increased opportunities to teach mathematics in an elementary classroom (Utley et al., 2005). As preservice teachers gain positive mastery experiences within structured and well-supported field experiences – providing them opportunities to engage students in

mathematics learning – higher levels of mathematics teaching efficacy may result (Johnson et al., 2018).

Measuring Mathematics Teacher Efficacy

Over the past 30 years, teacher efficacy has emerged as an essential construct in the education research field (Song et al., 2022) resulting in the development of multiple instruments to measure the self-efficacy of practicing and preservice teachers in various domains. Gibson and Dembo (1984) connected personal teaching efficacy with Bandura's (1977) conception of self-efficacy beliefs and posited:

> 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)

Tschannen-Moran and Hoy (2001), who criticized Gibson and Dembo's (1984) interpretation, developed the Teacher Sense of Efficacy Scale (TSES) to measure teacher self-efficacy across three factor—Instruction, Classroom Management, and Student Engagement—in a way they claimed more closely represented Bandura's (1986, 2001) theoretical framework. While the three-factor structure of the TSES has produced strong evidence as a sound measure for practicing teachers, data gathered from preservice teachers have not supported the proposed three factor structure (Tschannen-Moran & Hoy, 2001).

In agreement with Bandura's (1981) view of self-efficacy belief as being a situation specific rather than global construct, Enochs and Riggs (1990) developed the Science Teaching Efficacy Belief Instrument (STEBI) to specifically measure elementary teachers' efficacy beliefs in science teaching. Enochs et al. (2000) modified the STEBI to create the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI). The MTEBI was developed and validated specifically for preservice teachers and remains a widely used instrument for measuring the efficacy beliefs of preservice teachers (Swars et al., 2007). The MTEBI is a well-established instrument that has been translated for use in several international studies (Twohill et al., 2023).

Methodology

The purpose of this study was to determine elementary preservice teachers' self-efficacy beliefs regarding mathematics instruction. Since efficacy of experienced teachers is difficult to change (Hoy, 2000), preservice teachers' self-efficacy for teaching mathematics, which can be positively influenced by teacher education programs (Lee et al., 2017; Swars et al., 2007; Utley et al., 2005), is a credible indicator of their likelihood to provide effective mathematics instruction to their future students.

A descriptive, non-experimental research design was used to determine preservice teachers' self-efficacy for teaching mathematics. The study was conducted at a large public university situated in an urban city in the southeastern United States 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.

Participants

Participants in this study were a convenience sample of preservice teachers (n = 203) enrolled in a mathematics methods course prior to internship over two years. Participants were graduate and undergraduate students seeking initial teaching certification at the elementary (Kindergarten-6th grade) or Early Childhood (Preschool-3rd grade) level. The sample was mostly females (195 females, 7 males, and 1 nonconforming) who primarily self-identified as Caucasian (153 Caucasian, 34 Black or African American, 6 Hispanic or Latina, 4 Asian or Pacific Islander, 3 American Indian or Alaska Native, and 3 Other), which reflects the typical demographic configuration for individuals in these programs.

Instrument

The Mathematics Teacher Efficacy Beliefs Instrument (MTEBI) was used as the data collection instrument in this study (Enochs et al., 2000). The 21-item MTEBI uses a five-point, forced-choice response Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*) 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). The MTEBI is both a reliable and valid instrument as Enochs et al. (2000) established reliability with a Cronbach alpha coefficient of internal consistency of 0.88 for the PMTE scale and 0.77 for the MTOE scale. Using Confirmatory Factor Analysis, the two subscales were found to be independent of one another, establishing construct validity of the instrument (Enochs et al., 2000).

On the PMTE subscale, stronger personal mathematics teaching efficacy is denoted by higher scores, and higher scores on the MTOE subscale signify higher expectations of student achievement related to mathematics teaching. The PMTE scale consists of 13 items (2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, and 21), and the MTOE scale consists of eight items (1, 4, 7, 9, 10, 12, 13, and 14). The eight negatively worded items on the PMTE subscale (3, 6, 8, 15, 17, 18, 19 and 21) were reverse coded to correspond with the positively worded items. For this study, two demographic items—gender and ethnicity—were added to the instrument.

Data Collection and Analysis

The MTEBI was disseminated via Qualtrics^{XM} to preservice teachers enrolled in an elementary mathematics methods course during the first week of each semester for four consecutive semesters. A two-week window was available for responses, and a reminder email was sent at the end of the first week. To protect the confidentiality of respondents, no personally identifying information was gathered. Participants received an explanation of the purpose and notification that there were no identified risks or benefits for participating. Participants who completed the instrument were considered to have given their informed consent.

Quantitative descriptive statistics were calculated to organize and summarize the level of the participants' mathematics teaching efficacy as characterized by the data set. Subscale (PMTE and MTOE) and individual item means were calculated to measure central tendency. Range and standard deviation were calculated to measure variability.

Results

Overall scores (M = 51.2, SD = 4.2) for the PMTE subscale indicate that the participants have strong personal mathematics teaching efficacy, indicating they perceive themselves to possess the necessary skills and abilities to teach mathematics effectively. As shown in Table 1, the highest scored items on the PMTE were 2, "I will continually find better ways to teach mathematics" (M = 4.6, SD = .6) and 20, "When teaching mathematics, I will usually welcome student questions" (M = 4.5, SD = .6). Cronbach's alpha for the PMTE subscales (.727) verified the items are sufficiently consistent to indicate the measure is reliable.

Table 1. Personal Mathematics Teaching Efficacy Belief (PMTE) Subscale Results.

Item	Question	*M*	*SD*	Rank
2	I will continually find better ways to teach mathematics.	4.6	.6	1
3*	Even if I try very hard, I will not teach mathematics as well as I will most subjects.	4.0	.7	4
5	I know how to teach mathematics concepts effectively.	3.0	.8	8
6*	I will not be very effective in monitoring mathematics activities.	4.0	.6	4
8*	I will generally teach mathematics ineffectively.	4.0	.6	4
11	I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	3.6	.8	7
15*	I will find it difficult to use manipulatives to explain to students why mathematics works.	4.1	.6	3
16	I will typically be able to answer students' questions.	3.9	.6	5
17*	I wonder if I have the necessary skills to teach mathematics.	4.0	.6	4
18*	Given a choice, I will not invite the principal to evaluate my mathematics teaching.	3.8	.6	6
19*	When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	4.0	.6	4
20	When teaching mathematics, I will usually welcome student questions.	4.5	.6	2
21	I do not know what to do to turn students on to mathematics.	3.8	.6	6

Note. Reversed scored items are indicated with an asterisk (*)

Overall scores (*M* = 29.8, *SD* = 3.5) for the MTOE subscale indicate that the participants have a moderate level of expectation for positively impacting students' mathematics achievement through their teaching. As shown in Table 2, the highest scored items on the MTOE were 4, "When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach (*M* = 4.0, *SD* = .6), 9, "The inadequacy of a student's mathematics background can be overcome by good teaching (*M* = 3.9, *SD* = .7), and 10, "When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher" (*M* = 3.9, *SD* = .6). Cronbach's alpha for the MTOE subscales (.729) verified the items are sufficiently consistent to indicate the measure is reliable.

Table 2. Mathematics Teaching Outcome Expectancy (MTOE) Subscale Responses.

Item	Question	*M*	*SD*	Rank
1	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	3.7	.8	4
4	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4.0	.6	1
7	If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	3.2	.9	6
9	The inadequacy of a student's mathematics background can be overcome by good teaching.	3.9	.7	2
10	When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.	3.9	.6	2
12	The teacher is generally responsible for the achievement of students in mathematics.	3.7	.8	4
13	Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	3.6	.9	5
14	If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	3.8	.8	3

Discussion

Participants in this study reported high levels of self-efficacy regarding their mathematics teaching abilities. This finding is consistent with previous studies (e.g., Çakiroglu & Isiksal, 2009; Ozben & Kilicoglu, 2021; Zuya et al., 2016) that have found prospective teachers' perceptions of self-efficacy for mathematics teaching to be higher than average. The amount of mathematics teaching experience has been associated with higher self-efficacy (Ekmekci et al., 2015; Johnson et al., 2018); thus, preservice teachers' efficacy can change as they matriculate through their teacher education programs (Johnson et al., 2021; Lee et al., 2017). It is possible, therefore, that the mathematics teaching efficacy of the preservice teachers in this study, while already high, may increase after completion

of a mathematics methods course, additional field experiences, and internship. It is also possible, however, that increased opportunities to provide instruction to students could result in more realistic rather than higher perceptions of self-efficacy (Giles et al., 2013). Not surprisingly, preservice teachers' efficacy has been found to increase during their teacher preparation program and decrease during their first years in the classroom when faced with the challenges typically encountered when beginning a teaching career (Thomson et al., 2020; Thomson et al., 2019).

Preservice teachers in this study had moderate levels of efficacy regarding their abilities to positively influence students' mathematical achievement. Since data were collected at the beginning of the mathematics methods course, there had been no prior opportunities for the preservice teachers to implement mathematics instruction in an elementary or early childhood classroom. Hence, they may have felt less confident in impacting student learning with limited teaching experience. This is supported by Bandura's (1986) position that the personal success achieved through mastery experiences is the most powerful source of efficacy. Throughout the methods course and following into internship, the preservice teachers are afforded many opportunities to gain these mastery experiences, which may lead to improved outcome expectancy beliefs.

Conclusions and Future Research

While the results of this study indicated that these preservice teachers were confident in their ability to teach mathematics, they were less sure about the impact their teaching would have on students' mathematical achievement. Providing personal mastery experiences allowing preservice teachers to witness student success may significantly impact preservice teachers' mathematics teaching efficacy increasing their mathematics teaching outcome expectancy. The greatest implication from this study is the need for teacher educators to consider the importance of developing preservice teachers' self-efficacy beliefs regarding mathematics instruction when making program decisions, particularly regarding the format for mathematics methods courses and opportunities for teaching mathematics during field experiences.

As data were obtained from only one university, this study is limited in geographic sampling; thus, findings may not be representative to the whole state, region, or country. Additionally, the demographic characteristics of the participants may not be representative of a broader population, which limits the generalizability. Lastly, the data collection instrument was self-report, and, despite anonymity, it is possible that some participants may have provided responses that they felt were socially desirable.

Future research may consider the relationship between preservice teachers' mathematical efficacy and their own education to determine the influence, if any, of mathematics content courses, pedagogical mathematics courses, and early field experiences. Further, demographics such as gender, socioeconomic status, or ethnicity/race may have a role in determining self-efficacy beliefs regarding mathematics instruction, making future studies with more diverse participants desirable. Finally, research that connects preservice teachers' mathematical self-efficacy to the academic achievement of their students would be extremely valuable.

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