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Pre-service Teachers' Self-efficacy for Teaching Mathematics

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PRE-SERVICE TEACHERS' SELF-EFFICACY FOR TEACHING MATHEMATICS

by

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DISSERTATION

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DEDICATION

I dedicate this dissertation to all of my teachers, professors, and coaches whom have imparted in me a lifelong passion for learning along with the skills necessary to actualize my dreams. They were and continue to be my inspiration for choosing to pursue a career in education. I am thankful everyday for the exceptional education I have been fortunate enough to receive from the Albuquerque Academy and University of New Mexico. I also dedicate this to my Family – all people in my life who have supported me no matter what, who have always had my best interests in mind, who have fought for me and believed in me even when I was unable to.

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ABSTRACT

Teachers' self-efficacy beliefs start forming upon entering their teacher education programs and continue to develop throughout their first few years of teaching. They then remain relatively stable for the remainder of their teaching careers. Teachers' self-efficacy beliefs have been shown to influence teachers' job satisfaction, resilience, burnout rates, health, motivation, teaching behaviors, and students' academic achievement. It is important to understand how they form and what influences their development. The purpose of this study is to better understand the complex relationships involved during the formation PSTs' self-efficacy beliefs. The study examined the relationships between PSTs' self-efficacy beliefs for teaching and doing math, personal belief systems about math and teaching math, math content knowledge and mathematical knowledge for teaching, and how they relate to self-efficacy for teaching mathematics. Seven instruments and demographic questionnaire were administered 184 undergraduate students at a large university in the Southwestern United States.

Results of multiple regression analyses showed self-efficacy for doing math and teaching, math content knowledge and beliefs about teaching math were statistically significant predictors of self-efficacy for teaching mathematics. Surprisingly, mathematical knowledge for teaching was not a statistically significant predictor. In terms of self-efficacy beliefs, there were distinct differences between self-efficacy for teaching and self-efficacy for doing math. Combined they predicted 48% (adjusted) of the variance found in self-efficacy for teaching mathematics. The results highlight the importance for teacher education programs to explicitly address pre-service teachers' self-efficacy beliefs, personal beliefs systems about teaching math, and increase the depth of understanding of math content knowledge.

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CHAPTER 1

INTRODUCTION

"Self-efficacy beliefs are most likely to change during skill development, when individuals are faced with novel tasks (Usher & Pajares, 2006, p. 752).

Study Background

Given the consistent shortage of teachers in the field, math teacher is one of the most difficult positions in K-12 education to fill. This shortage has led to the trend of hiring any teacher meeting the basic qualifications, or in situations where waivers are permitted to be used, any willing teacher (qualified or not) gets the job. I myself was hired as the 6th grade language arts teacher, only to be told 3 days before school started that I would be teaching 7th grade math and science. The administration had accidentally hired two teachers for the same position, and they felt I was more qualified to teach math and science than the other teacher. I was faced with the option of having a job I was not qualified for or not having a job at all Consistent with research findings (Tschannen-Moran & Woolfolk Hoy, 2007; Woolfolk Hoy & Spero, 2005), as a pre-service teacher I had high self-efficacy for teaching beliefs, overinflated really. I had good math and science teachers to use as models, and I felt confident in my knowledge of middle school math and science, so I agreed to take the job.

Needless to say, I had no real comprehension of the challenges that lay ahead of me. Throughout the year, everyday felt like I was going unarmed into an unwinnable battle. The external factors were deplorable: first year charter school, unfinished facilities, no textbooks or teaching resources whatsoever, and I, alone, was responsible for developing the curriculum using only the state's standards and benchmarks. Within my classroom, I had two groups of 27 students with math abilities ranging from pre-K to post-high school. The majority of my students already had negative experiences and attitudes about learning math. One student had never seen long division. Another student had a desk drawer full of completed math homework she never turned in because her former math teacher frightened her. The difficulties I encountered and dealt with as a (new) teacher are too many to recount, but the bottom line is that I was dealing with so much more than just trying to teach my students how to convert fractions to decimals.

There were several things I encountered that year that stood out in terms of my students' mathematics educations. First and foremost was the degree to which students' math knowledge was determined by the quality of their prior math teachers. Too much was due to chance! Additionally, many of my students were suffering from a lack of exposure to mathematics instruction and practice. Some recounted having been told by their former teachers that they could not learn division or any math beyond basic multiplication until they had their multiplication tables memorized (the majority did not know them). A common theme was a basic lack of grade level knowledge, and many reported not being taught math everyday, or very much at all. The majority of my students appeared to have been written off at some point as needing too much help, being too far behind, and some reported having been explicitly told they just could not learn math.

Initially, not believing what I was hearing from my students, I began to ask my friends who were elementary teachers if they taught math everyday, and how much time they spent teaching math. To my surprise, a large portion reported not teaching math everyday, or not devoting as much time to teaching math as much as they gave to other subjects. There were a variety of reasons listed as to why math was taught less than the other subjects but the core of all the reasons given was that they thought teaching reading and writing was more important, and teaching math was not a priority. My worst fears were becoming true: how much the students knew about math, their beliefs about math, and their self-efficacy for learning and doing math were largely dependent on their prior educational experiences in math, which were largely based on who their math teachers were. By random chance, some students had been fortunate enough to have at least one good math teacher. But on the other side of chance, the remaining students had exclusively had negative math learning experiences, or had been exposed to poor beliefs about math and/or inconsistent and inadequate teaching practices. How can the chance that students will get an effective math teacher be improved?

Trying to overcome the negative effects bad teaching had on my students' relationships with math was a long and trying process, and was seemingly insurmountable at times. My grade-level lesson plans were lost on all but three students. When students enter the math classroom grade levels behind, with negative beliefs about math, and maladaptive self-beliefs related to learning math, they are likely to be closed off to learning. Having a good lesson plan is essentially irrelevant if few to none of the students are paying attention. Through that lens, being an effective math teacher involves much more than just teaching multiplication, division and fractions (Ball, Hill, & Bass, 2005). How can teacher education programs better prepare teachers to teach math? What is effective in making teachers believe themselves capable of teaching math?

We live in an era where the acquisition of information can be accessed in seconds using a smartphone and the Internet. Students' learning needs and the challenges teachers encounter are much different than they were only a decade ago. The majority of students' needs have shifted from gaining access to information to learning how to manage the influx of information vying for their constant attention. Students now have access to all the information they will ever need regardless of which teachers they get or what schools they attend.

The role of educators has changed. The learning needs of students have changed. Advances in technology have led to drastic changes in societal norms, like how we communicate with one another. Yet our education systems have not changed, leaving both teachers and their students with unmet learning needs. Formal education used to be, and in many cases continues to be, a formerly agreed upon exchange, wherein students exchange their time, energy, and attention to gain access to the knowledge the teacher possesses. Thus knowledge was not available elsewhere or it was difficult to obtain from other sources. Thus the best students became the teachers, because they demonstrated the most mastery of the content knowledge. Now that access to content knowledge is instantly available to anyone with an Internet connection, the role of teachers has changed. The knowledge required to be a teacher has changed and/or become more essential to students' learning needs. Students do not need access to the information, they need to be taught the skills how to filter, use, think about, analyze, be critical of, and navigate the overwhelming amount of information vying for students attention at any given moment (Ball et al., 2005). The challenges teachers face are much different than the challenges their teachers faced only a decade ago.

The rapidity of social and technological change is placing teachers, especially pre-service and novice teachers, into a new and unknown educational frontier with limitless potential and they've been told to bring calculators along with their outdated textbooks. The need for teachers to have high perceptions of self-efficacy, personal efficacy, self-efficacy for teaching, and collective self-efficacy has never been more apparent. Teachers are faced with countless novel situations everyday, and in many cases, social norms have yet to be established. “The self-efficacy beliefs students hold when they approach new tasks serve as a filter through which new information is processed (Usher, Pajares, & Urdan, 2008, p. 754). When deciding on a course of action or in acting itself when in novel situations, it is teachers’ self-efficacy beliefs that largely determine what happens next.

Purpose

> Success in difficult undertakings requires perseverant effort in the face of many stressful and aversive elements (Bandura, 1988, p. 487).

Teaching math is a challenging endeavor. It is challenging regardless of teaching experience, math knowledge, and math content area or level being taught. Math can be a difficult subject to learn, especially the formal ways in which we teach math that do not always align with children’s mathematical thinking. Math is a natural part of our existence, yet it is often taught as though it is a mysterious and enigmatic entity. Negative or maladaptive beliefs about math are commonplace (R. A. Philipp, 2007). Math is perceived as a subject only the smartest students can understand. There are many who believe that some students are just not good at math and therefore cannot learn it. There is also an oft stated belief that math is not useful outside of school so there is no reason to teach it. Some students and teachers feel anxious about learning and doing math, and their anxiety hinders their ability to learn math. Math is thought to be only about getting the correct answer, so all students need to do to be successful is memorize formulas and procedures for solving problems correctly, and math teachers merely need to teach them those formulas and procedures and when to use them. There is no reason or need to teach a deeper understanding of and conceptual knowledge for math beyond what will if it is not essential to the majority of careers. Math is boring. I cannot do math. These are a small sample of the thoughts and feelings racing through the heads of students in a math class, and these are only the ones related to math!

Teaching math involves more than just teaching math. There are a multitude of challenges facing math teachers in addition to teaching the required content. These include: difficult students and/or poor student attitudes toward learning math, inadequate teacher training to teach math, insufficient math content knowledge, classrooms made up of too many students with diverse learning needs, varying math abilities and backgrounds. One study found that compared to elementary and high school educators, middle school math teachers were particularly ill prepared and trained to teach math and had inadequate math knowledge to teach the level of math they were teaching (Saderholm, Ronau, Brown, & Collins, 2010). Elementary self-contained classrooms decide how often and how much math is taught to their students. Since positive self-efficacy beliefs are related to proactive behaviors, persistence, motivation, and positive affect and physiological states, having positive self-efficacy beliefs for teaching mathematics are essential to being an effective math teacher. Self-efficacy beliefs seem like they would be related to the amount of time teachers spend teaching math as well as the quality of that instruction. In situations where only the individual teachers determine what is taught, how it is taught, and when it is taught, their self-efficacy beliefs about their own capabilities to teach math become even more important.

Mathematics is a subject where learning involves making mistakes and learning from those mistakes. In a content area where a common belief is getting the correct answer is the goal, where aptitude is measured by number of correct answers, it is difficult to get teachers and students to embrace making mistakes as valuable learning opportunities. In order to be able to turn mistakes into learning opportunities, a deeper understanding of the content being taught is needed. Learning from mistakes requires examination of thought processes and beliefs systems to gain understanding about why the mistake was made and how to correct it. To do this requires skill, knowledge, and positive self-efficacy beliefs.

What constitutes a teachers' self-efficacy for teaching math? When it comes to teaching math, there may be at least three different self-efficacy beliefs at work: self-efficacy for teaching, a self-efficacy for doing math, and the more specific self-efficacy for teaching mathematics.

Do self-efficacy for teaching and self-efficacy for doing math predict self-efficacy for teaching math? Do elementary math PSTs have lower self-efficacy for teaching math than secondary teachers? Since elementary teachers teach all content areas and have more responsibility over one group of students' learning, do PSTs with an elementary level target license have a higher self-efficacy for teaching than secondary PSTs? Is there a relationship between beliefs, knowledge and self-efficacy? Do beliefs, knowledge, and self-efficacy predict self-efficacy for teaching math? Do demographic characteristics combined with beliefs, knowledge, and self-efficacy predict self-efficacy for teaching math?

Rationale

Perceived self-efficacy is an individual's belief about his/her own capability to execute an action in a given situation. It is the degree to which a person believes they can do something, and it influences how a person behaves, feels, thinks, and makes choices (or decisions). "Self-efficacy beliefs affect the quality of human functioning through cognitive, motivational, affective, and decisional processes" (Bandura, 2012, p. 13). Self-efficacy beliefs are related to behavior, achievement, attributions, and motivation. Self-efficacy predicts students' choice of college major and career aspirations (Lent & Brown, 2006). Self-efficacy predicts students' academic achievement across all ability levels and content areas (Urdan & Pajares, 2006). Self-efficacy for teaching predicts stress, burnout, and job satisfaction (Fives, Hamman, & Olivarez, 2007; Skaalvik & Skaalvik, 2010). Self-efficacy for teaching is also related to perceived success, perceived difficulty of teaching assignment, and perceived level of support (Woolfolk Hoy & Spero, 2005). Self-efficacy for math predicted mathematics motivation, performance, and their intention to enroll in additional math courses (Stevens, Olivarez Jr, Lan, & Tallent-Runnels, 2004). Given the available data, one cannot underestimate the importance of self-efficacy and its role in effective teaching.

Self-efficacy beliefs are not a universal characteristic, and there are different types and levels depending on the domain and context. Of interest to this study is self-efficacy for teaching, and to be more specific, pre-service educators' self-efficacy for teaching mathematics. Self-efficacy for teaching influences how a teacher thinks about teaching, what they teach, the manner in which they will teach, how effective (or ineffective) they feel their teaching will be, their motivation to teach, the goals they set for themselves and their students, and their resiliency to endure the difficulties of the profession.

Elementary teachers are often responsible for students' first introduction to the formal learning of mathematics. Teachers that have a positive relationship, affect, and beliefs about math will positively influence their students' perception of mathematics, while a negative teacher will cast a negative shadow over math that many students may never get out of. By the time students leave elementary school, their interest in math has peaked and the steady decline in interest, knowledge, and performance begins (Stevens, Olivárez, & Hamman, 2006). It is essential that students' initial experiences in formal mathematics education are positive ones, and it all starts with their teachers.

Who teaches pre-service teachers how to teach math, and the department and the available professors largely determine what they are taught in their math for teachers courses. A mathematics for teaching course offered in the mathematics department taught by a mathematics professor tends to focus on mastery of content knowledge, whereas a similar course offered in the teacher education department may focus more on pedagogy. Additionally, the amount of actual K-12 classroom teaching experience of the course professor/instructor is not guaranteed, with their K-12 classroom teaching experience ranging from none to decades of experience (Masingila, Olanoff, & Kwaka, 2012). Research had found that pre-service teachers (PSTs) are being taught how to teach math either by mathematicians, or professors of education, both of who have may or may not have experiences teaching math in a K-12 classroom. How, what and by whom PSTs are taught to teach math varies to such an extent it has led to inconsistent and ineffective teaching beliefs and practices.

Self-efficacy

Self-efficacy, which is an individual's belief about his/her own ability to successfully perform a given task, is related to an individual's choices, performance, effort, persistence & affect (Usher et al., 2008). Within education, self-efficacy predicts students' academic achievement (Urdan & Pajares, 2006)), college majors & career choices (Lent & Brown, 2006), and other motivation related constructs such as achievement goal orientations, attributions, task related affect, self-regulation, self-concept & self-determination (Usher et al., 2008). Within the context of teaching, self-efficacy is related to both the teachers' and their students' mathematics behaviors, motivation, beliefs, value and knowledge (Klassen, Tze, Betts, & Gordon, 2011). Self-efficacy for teaching has also been found to predict job satisfaction and teacher burnout (Skaalvik & Skaalvik, 2010).

While the existing research literature shows the importance of self-efficacy, little is known about how self-efficacy is formed. Due to the nature of the construct, self-efficacy is complex and difficult to measure, especially in that it requires a certain level of domain and level of specificity. Self-efficacy interacts with, and is related to other constructs such as beliefs and knowledge, but little is known about these relationships and the possible factors predicting self-efficacy. "Studies of the sources of self-efficacy will be enriched by attending to students' habits of thinking – their predispositions toward viewing the world and their preconceptions about school, learning, and their academic selves. Knowledge, competence, and various forms of self-knowledge and self-belief act in concert to provide adequate judgments and interpretations of efficacy building information" (Usher et al., 2008, p. 790).

Beliefs and Self-efficacy

Individual beliefs systems are complex and multidimensional. Examination of beliefs should be done at a domain specific level (Pajares, 1992). The "beliefs teachers hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom, or that understanding the belief structures of teachers and teacher candidates is essential to improving their professional preparation and teaching practice" (Pajares, 1992, p. 307).

In a meta-analysis of the research literature on mathematics beliefs, Allen (2007) discovered four common themes: through prior formal schooling, students have already formed math belief systems; these belief systems do not align with the standard math curriculum; there are patterns of math beliefs that exist across a variety of ages, abilities, and nationalities; and traditional instruction is ineffective in changing students' math belief systems.

Before undergraduate students decide to become teachers, they enter teaching programs with strongly held beliefs systems about what mathematics is and what it means to be a teacher of mathematics. A common assumption is that although students come to learn with their existing belief systems, but that their belief systems will change as they learn. However, researchers have found the opposite to be true: students existing belief systems are resistant to change (Cooney, Shealy, & Arvold, 1998; R. A. Philipp et al., 2007). When the students' beliefs did not align with the curriculum they are learning, instead of reconciling the difference, they compartmentalized what they learned in a way that preserved their existing beliefs. Thus, a majority of pre-service teachers are graduating from their teacher education programs with the same belief systems with which they entered.

When it comes time for these future teachers to make decisions and engage in teaching behaviors, their decisions will be based more on their existing belief systems than the knowledge learned through their teacher education courses (Confrey, 1990; Raymond, 1997). Unless their teacher education programs formally address and examine these beliefs and misconceptions, and help them develop a new system of beliefs, pre-service teachers will hold on to and pass along their existing beliefs and misconceptions to the next generation(s) of students.

Self-efficacy and Knowledge

There are several types of knowledge teachers must possess to be effective teachers of mathematics content knowledge, specialized content knowledge, pedagogical content knowledge, and mathematical knowledge for teaching, (Ball et al., 2005; Hill, Rowan, Ball, & Loewenberg, 2005; Holmes, 2012). Math learning does not occur in a bubble and teachers have to work with the existing beliefs and prior knowledge of each of the students in their classrooms. Knowledge of student beliefs, misconceptions, typical errors, frequently used strategies, and the ability to diagnose students' abilities, prior knowledge, knowledge gaps, and strategies are thus a core component of mathematical knowledge for teaching. For example, knowledge of common errors and mistakes provide valuable insights into students' implicit knowledge (Vosniadou & Verschaffel, 2004).

In a study to validate psychometric properties of the Diagnostic Teacher Assessment in Mathematics and Science (DTAMS) middle school mathematics assessment, the researchers found that, "Average teacher scores on these assessments of 50% indicated that middle-school mathematics teachers who completed the assessments knew approximately 50% of the content necessary to teach mathematics to their students. On all tests across content subcategories, only approximately 17% of teachers scored higher than about 70%" (Saderholm et al., 2010, p. 187). We expect math students to learn grade level mathematics when the average middle school math teacher knows approximately half of the mathematics content they are supposed to teach, and are considered to be even less proficient.

Polya (1959) said, "The prospective teacher is badly treated both by the mathematics department and by the school of education. The mathematics department offers us tough steak which we cannot chew, and the school of education vapid soup with no meat in it" (p. 61-69). The so called "meat" that is missing from many teacher education programs are the beliefs that teachers require a specialized knowledge to teach mathematics, teachers need to understand how children think mathematically before they are in school, and how students actually learn mathematics in school. The difference in beliefs is the emphasis on: learning what effective mathematics teaching is, why the teaching methods are effective, understanding how students learn and think about math, and learning how to teach mathematics effectively in a manner that promotes students' mathematical learning over their performance. As Adler et al (2005) stated in a discussion over the future direction of research in mathematics teacher education, "We do not understand well enough how mathematics and teaching, as inter-related objects, come to produce and constitute each other in teacher education practice" (p. 378).

Summary

This study will examine some of the ways in which self-efficacy beliefs, personal beliefs systems, and knowledge interact and influence each other, with particular attention focus on how they relate to the formation of self-efficacy beliefs about teaching mathematics. This study will contribute to the call for research on self-efficacy for teaching (Klassen et al., 2011) in the following ways:

1. Using more statistically complex research methodologies, in this case, multiple regression analyses and multivariate analysis of variance.
2. Achieving a better understanding of the sources of self-efficacy by looking at its relationships with difference domains and levels of self-efficacy, belief systems, and types of knowledge.
3. Increasing what is known about different domain and level specific self-efficacy, in this case, self-efficacies for teaching, doing math, and teaching math.
4. Increasing what is known about self-efficacy in cultures other than ethnically White North American populations, in this case, Hispanic pre-service teachers in the

southwestern United States where their population is equal to or greater then the White population.

5. Increased knowledge about pre-service teachers self-efficacy and development of self-efficacy.
6. Conducting self-efficacy research using theoretically aligned instruments proven to be reliable and valid, or created to be consistent with theory and Bandura's guides for constructing self-efficacy scales.

CHAPTER 2

LITERATURE REVIEW

Selection of Literature Reviewed.

Articles published in the year 2000 or later were given preference in order to review studies conducted after it was generally accepted in the field that the instruments used up to that point were not effective or reliable measures of a teacher's self-efficacy, beliefs, or knowledge. Since around the year 2000, multiple efforts have been made to design new sets of instruments to measure the following constructs as they relate to the teaching of mathematics: self-efficacy (Bandura, 2006; Dellinger, Bobbett, Olivier, & Ellett, 2008; Labone, 2004; Pajares, Hartley, & Valiante, 2001; Tschannen-Moran & Woolfolk Hoy, 2001; van Dinther, Dochy, Segers, & Braeken, 2013), beliefs (Ambrose, Clement, Philipp, & Chauvot, 2004; Cooney et al., 1998; S. A. Karabenick & Maehr, 2007; R. A. Philipp et al., 2007), and knowledge (Adler et al., 2005; Bell, Wilson, Higgins, & McCoach, 2010; Bush, 2005; Copur-Gencturk & Lubienski, 2013; Hill, 2010; Hill et al., 2005; Holmes, 2012; Linsell & Anakin, 2012; R. A. Philipp et al., 2007; Saderholm et al., 2010)

Initial search terms used to find articles began with the main constructs, self-efficacy, teacher-efficacy, beliefs, knowledge, then narrowed down by focus/content area and their various iterations. For example, for a search relating to self-efficacy, the following terms were used: "self-efficacy", "teacher efficacy" "teacher self-efficacy", "self-efficacy for teaching", "math self-efficacy", "self-efficacy for teaching math". From those results, the best matching articles, most cited articles, and articles published in the most prestigious journals were reviewed for relevance, retrieved, and saved for further review.

Subsequent search rounds relied on information discovered from the articles retrieved during the initial round. For example, several of the articles discovered in the first round of searches related to self-efficacy for teaching either used or referred to an instrument called “the Teachers’ Sense of Efficacy Scale” or TSES. Since that was a self-efficacy instrument of interest, the search terms “Teachers’ Sense of Efficacy Scale” and “TSES” were used in subsequent searches. Additionally, authors who were commonly cited in the relevant self-efficacy literature were also used as search terms, both as authors and in terms of a general word search: “Bandura”, “Tschannen-Moran & Woolfolk Hoy”, “Pajares”.

Final search rounds involved referring to reference lists of the previously retrieved articles and conducting on-line searches outside of the electronic library and educational databases used in prior rounds. Instead the searches were conducted using Google scholar. The process for searching using Google Scholar followed the same steps and procedures as outlined above. The Google searches helped to discover grants and research projects dedicated to the research and design of assessments of teachers’ self-efficacy, beliefs, and knowledge. The discovery of the grants and projects was invaluable as they contained newly developed assessments that were not discovered through the academic searches, and ultimately led to the development of several instruments used in this study.

Articles that were either about instruments known to be ineffective, or studies that used those same instruments, were excluded from review. For example, in the field of teacher’s self-efficacy, there is an instrument used extensively and still being used today, although it has been repeatedly found to be an ineffective measure: The Teacher Efficacy Scale (TES) by Gibson and Dembo (1984).

The TES instrument suffers from reliability issues, poor construct validity, and measurement error issues (Heson, Kogan, & Vacha-Haase, June 2001), yet continues to be used in spite of the known and reported issues. Studies using the TES to measure the construct teacher self-efficacy were excluded from review, with the exception of articles using it in conjunction with other self-efficacy measures. Only studies using the TES as one of several instruments being compared and analyzed to determine factor structures, reliabilities, and validities were retained for later review. Another instrument found to have poor properties but a high level of usage was the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), whose fundamental design was based on modifying the TES. So while the TES and MTEBI are instruments that would commonly be used in a study similar to this one, they will not be included in the review of literature or utilized in the study.

Self-efficacy

"Self-efficacy beliefs affect the quality of human functioning through cognitive, motivational, affective, and decisional processes" (Bandura, 2012, p. 13).

The importance of the self-efficacy beliefs of teachers cannot be underestimated. Self-efficacy beliefs influence teachers' cognition, motivation, affect, and choices. These beliefs play a role in their outlook on life, whether they are an optimist or pessimist, and the degree to which they have self-enabling or self-debilitating attributes for their failures and successes. Teacher's self-efficacy beliefs influence their level of motivation and perseverance, the goals they set for themselves, and their self-regulation of emotional states. They also influence teachers' job satisfaction, vulnerability to stress and depression, and their self-perceptions of teaching effectiveness (Caprara, Barbaranelli, Steca, & Malone, 2006; Skaalvik & Skaalvik, 2010). The choices teachers consider and the choices teachers make are rooted in their self-efficacy beliefs, and whether or not they think themselves capable of successfully exhibiting effective teaching behaviors.

Self-efficacy and Social Cognitive Theory

"People create social systems, and the authorized rules and practices of social systems, in turn, influence human development and functioning" (Bandura, 2012, p. 15). Grounded in social cognitive theory, self-efficacy beliefs are of an agenic perspective (Bandura, 2012), meaning they are the areas in which individuals have the power to assert control over, or have personal agency over their future outcomes. As Bandura (2012) explains, in social cognitive theory's "triadic codetermination, human functioning is a product of the interplay of intrapersonal influences, the behavior individuals engage in, and the environmental forces that impinge upon them" (p. 11) Interpersonal, behavioral, and environmental factors interact in a combination of bidirectional relationships to influence human functioning. Understanding the complex interplay occurring between individuals' interpersonal attributes, behaviors and the environment sheds light on why humans do the things they do. If the environment is a mathematics classroom, and the behaviors are teaching math, then understanding the interpersonal attributes of teachers like self-efficacy, knowledge and personal beliefs systems of teachers would benefit teacher education programs. Exposure to experiences teaching in effective learning environments help pre-service teachers develop adaptive teaching behaviors along with healthy, realistic and positive self-efficacy beliefs for teaching math.

Looking through the lens of social cognitive theory, where teacher education programs can have the most impact on the development of effective math teachers, is in the intrapersonal realm. Teachers do not always choose their teaching environment. The profession of teaching involves hundreds of unplanned split-second decisions and behaviors every day. Lesson plans rarely go exactly as planned. It is impossible to plan for every possible situation and anticipate every possible students' questions, behaviors, and responses. It is teachers' intrapersonal attributes that influence their teaching behaviors. Teachers' behaviors in the math classroom influence their students' academic achievement in math and level of mathematics anxiety, which influences the development of their own students' self-efficacy for doing math.

Self-efficacy Defined

Self-efficacy is an individual's perception of his/her own capability to execute an action in a given situation. "Self-efficacy is concerned with perceived operative capability" (Bandura, 2007, p. 651), the "can do" belief individuals assert in order to execute meaningful actions. There are different types of efficacy and they "vary across activity domains and situational conditions rather than manifest uniformly across tasks and contexts in the likeness of a general trait" (Bandura, 2012, p.13). The two main types of efficacy, personal efficacy aka self-efficacy and collective efficacy. As stated above, personal efficacy is a self-belief about one's own capability to act successfully in a given situation. Collective efficacy is the belief people hold about the shared capabilities of the social groups and/or organizations to which they belong. Of interest in this study are pre-service teachers' (PSTs), self-efficacy beliefs to teach, do math, and teach mathematics, as well as their beliefs and knowledge of math and teaching math.

Capability and ability are not synonymous as Bandura (2007) points out, "Able denotes mere possession of ability or capacity" (Bandura, 2007, p. 652). Capability involves personal agency, the "can do" belief needed for action. A person may possess the abilities needed to learn math – they can read, they can write, they know their numbers, they can pay attention, but if they do not believe themselves capable of learning math, mere possession of these abilities is inconsequential. Klassen et al. (2011) further distinguish self-efficacy from other types of self-beliefs, in that "beliefs about self-efficacy reflect judgments of *capability*, beliefs about self-concept refer to beliefs about current *ability*, and beliefs about self-esteem reflect self-worth" (p. 26). It is important for teacher education programs to focus on the development of teachers' beliefs and perceptions of their math teaching capabilities.

Sources of Self-efficacy Beliefs

According to Bandura's theory of self-efficacy (1997) there are four sources from which self-efficacy beliefs are developed: mastery experiences, social modeling (formerly vicarious experiences), social/verbal persuasion, and physiological and affective states. Mastery experiences include the acquisition of knowledge, skill development and refinement, practice, performances, typically formal learning and educational experiences. Social modeling involves instances in which learning occurs indirectly, not by the learner doing but by the learner watching. Pre-service teachers learn by watching teachers teach. The quality of learning is dependent on the model being watched, the perceived expertise, the similarity of the model to the learner, and the ability of the learner to envision themselves as the model. Social or verbal persuasions include the feedback and messages a learner receives. Pre-service teachers are likely to have received affirming messages about the virtues of teaching as a career to pursue and feedback that they themselves would be a good teacher. Physiological and affective states acknowledge the influences our bodies have over our experience and memories. Students having experienced unpleasant mathematics learning environments may suffer from mathematics anxiety when those memories are triggered (Austin & Wadlington, 1992)

There are a variety of ways researchers refer to the various types of self-efficacy beliefs, so some clarification of terms is needed. Bandura refers to self-efficacy as "perceived self-efficacy" but then states that for literary acumen will use "self-efficacy". Usher et al. (2008) use the terminology "self-efficacy beliefs" throughout the entirety of their article. The term "teacher efficacy" was used by Klassen et al. (2011) as an umbrella term covering teachers' self-efficacy beliefs and teachers' collective efficacy beliefs. When in the domain of teaching, another term commonly used is "teachers' sense of efficacy" (Tschannen-Moran & Woolfolk Hoy, 2001). For the purposes of this study, all types of personal efficacy beliefs will be referred to as "self-efficacy for '*x*' : self-efficacy for teaching, self-efficacy for doing math, and self-efficacy for teaching math. Collective efficacy is beyond the scope of this study, but does appear in the literature review and in the discussion chapter in directions for future research.

Self-efficacy Research

In a longitudinal study of the development of teacher efficacy beliefs, or as they are referred to in the following study review, researchers Woolfolk Hoy and Spero (2005) measured teachers' sense of efficacy beliefs at three points in time: pre-service, student teaching, through the first year of teaching. At the time of their data collection, there were still no proven measures of teacher efficacy or self-efficacy for teaching. In order to protect their study from the consequences of using measures with poor psychometric properties and gain validity and reliability information for newer measures, four different measures of teacher efficacy were used and compared.

The first instrument contained two measures, one for personal teacher efficacy (PTE) and one for general teacher efficacy (GTE). The instrument combined items from the earliest two measures widely used in teacher efficacy research: the two-item RAND (1978) instrument and the Teacher Efficacy Scale (TES) by Gibson and Dembo (1984). Both instruments suffer from psychometric and theoretical validity issues, but have been so widely used in the literature, including them in their study for the purposes of gaining a better understanding of what exactly the items were measuring was justified. The second instrument is Bandura's (2006) 30-item teacher self-efficacy scale, which prior to this study had not been used with pre-service teachers. The third instrument is a newly created Ohio State Teacher's Confidence Scale.

The researchers sought to answer how teacher efficacy beliefs develop and change over time and what factors were related to the teachers' sense of efficacy beliefs. They then compared and contrasted the four different measures of teacher efficacy beliefs. The results of the study indicated a trend in the development of teacher efficacy beliefs over time. The trend showed a high self-efficacy for teaching before student teaching, which peaks after student teaching, and plummets during their 1st year teaching, falling to below the initial pre-service teachers' values (Woolfolk Hoy & Spero, 2005). The trend was consistent with prior research findings in that pre-service teachers have a higher self-efficacy for teaching than novice teachers, and that there is a statistically significant drop in teachers' self-efficacy beliefs during their first year of teaching (Tschannen-Moran & Woolfolk Hoy, 2007).

This drop in self-efficacy for teaching during the initial year of teaching may be due to pre-service teachers tendency to "underestimate the complexity of the teaching task and their ability to manage many agendas simultaneously" (Woolfolk Hoy & Spero, 2005, p.

353). They also surmised the decline could be due to the withdrawal of mentoring support that occurs when teachers enter their own classrooms. The greater level of perceived support decreased the difficulty rating of their teaching assignment. Novice teachers' perceived satisfaction with their performance changed in the same direction as their efficacy beliefs: as satisfaction increased, so did their teacher efficacy. They also found that perception of success was negatively correlated with their students SES. The lower their students' SES were, the higher the reported perceptions of achievement went (Woolfolk Hoy & Spero, 2005).

Along the same lines, the study found that the novice teachers who reported having satisfactory mentoring support during their rookie year were more likely to be teaching at schools where students have higher SES. Teachers teaching at the schools with the fewest students on free or reduced lunch had the highest levels of perceived support. The importance of mentoring programs for novice teachers was emphasized, especially at low SES schools. It was found that as perceived support increased, so did perceived teacher efficacy (Woolfolk Hoy & Spero, 2005). The study highlights the important of the teaching environment on teachers in their perceived experiences and teacher efficacies.

Teachers' collective efficacy beliefs are the beliefs teachers' hold about their colleagues' and school's capability to teach their students. It is the judgment of an entire school – the perceived beliefs as to whether or not the teachers can meet the needs of their students and teach them effectively. Teachers' collective efficacy beliefs "are an emergent group property that influence how teachers in a school cope with a variety of challenges" (Klassen et al., 2011, p. 23). The researchers call for increased attention to be paid to teacher's collective efficacy, however, consistent with the literature reviewed, it was beyond the scope of this study.

The study involved a meta-analysis of all teacher efficacy research published in peer reviewed North American journals from 1998-2009. A new wave of teacher efficacy research emerged after calls went out for additional studies to be conducted on self-efficacy for teaching. Prior to this wave of research, what was needed were studies using new instruments, varying research methodologies (qualitative, longitudinal, quasi-experimental, mixed methodology), and aligned with Bandura's theory of self-efficacy. A large body of research on teacher efficacy has transpired since then, and Klassen et al. (2011) reviewed a total of 218 articles. They examined changes in teacher efficacy research trends over time, summarized proposed directions for future research, examined the variety of methodologies used and the frequencies of their use, looked at the findings related to the sources of teacher efficacy, which academic domains have been studied and which are lacking, the degree to which teacher efficacy research has been internationalized, and if and how the conceptualization and measurement issues have been resolved.

To examine if there were any changes in research trends from the prior decade, they looked at he diversity of research methodology used, domain specificity, presence of collective efficacy and the degree to which teacher efficacy research has gone international, by counting and categorizing number of articles published per year. They found the lowest mean for studies including collective efficacy ($M = 1.33$) compared to means approximately four times higher for studies using qualitative and mixed methods ($M = 4.17$), domain-specific focuses ($M = 5.67$), and studies published in international journals ($M = 7.92$). Compared to the prior decade, the mean total number of studies involving teacher efficacy published per year increased three-fold from 5.7 articles per year to 18.2 per year (Klassen et al., 2011). Their findings show that the importance and benefits of teacher efficacy research have been realized, especially within the international research community. They also found statistically significant increases in the publication of teacher efficacy studies in diversity of methodology, domain specificity, internationalization, and inclusion of collective efficacy. However, because the increases could have merely been due to the overall increase in number of teacher efficacy studies published from the prior decade, they decided to examine the proportional increases by category. There were statistically significant changes in the proportion of internationalization and occurrence of collective efficacy research. There were no changes in the proportion of domain specific studies or the diversification of research methodologies used.

Measurement Issues in Self-efficacy Research

Researchers of teacher self-efficacy and teacher efficacy have written extensively about why the prior instruments are ineffective, inadequate, and suffered from poor construct and theoretical validity (Dellinger et al., 2008). The Teacher Efficacy Scale (TES) by Gibson & Dembo (1984), Bandura's Teacher Self-efficacy Scale (1996), and the 2-item RAND instrument (1978) were the most frequently cited instruments used in the teacher self-efficacy literature and were also the most cited for needing improvement (Dellinger et al., 2008; Fives & Buehl, 2009; Heson et al., June 2001; Klassen et al., 2011; Pajares, 1992; Tschannen-Moran & Woolfolk Hoy, 2001; Usher et al., 2008; Woolfolk Hoy & Spero, 2005).

These misunderstandings have led to one of the recurring issues with self-efficacy research: lack of construct and theoretical validity. In studying the theorized four sources of self-efficacy, researchers have used course grades, test scores, asked participants to quantify their experience, and other outcome related variables to measure the construct mastery experiences, instead of the individuals' self-perception about these experiences (Usher et al., 2008). An individual's performance or ability to perform is not self-efficacy. Self-efficacy is that individual's perception or belief about their capability to perform. Actual skills and scores are inconsequential if they are not aligned with their self-efficacy judgments. For example, a student receives a 95% on a math test, the best score out of all the other students, but if that student sees his/her performance as a failure in not having achieved a perfect score, and self-efficacy might suffer. "The same level of performance success may raise, leave unaffected, or lower perceived self-efficacy depending on how various personal and situational contributions are interpreted and weighted (Bandura, 1997, p. 81). It is the self-belief component of self-efficacy that is often overlooked and appears to be the most prescient.

To address the measurement issues in self-efficacy research, several new measures have been developed, refined, and tested in the past decade, two of which are used in this study. The Teachers Sense of Efficacy Scale (TSES) (Tschannen-Moran & Woolfolk Hoy, 2001) and the Self-Efficacy for Teaching Mathematics Instrument (SETMI) (McGee & Wang, 2014) were used in this study, their use supported by the growing body of literature citing their sound psychometric properties and construct validity(Duffin, French, & Patrick, 2012; Fives & Buehl, 2009; O'Neill & Stephenson, 2012). This study will contribute to the literature by adding what is known about using the instrument with pre-service teachers and culturally diverse populations, in this case, Hispanic students.

Self-efficacy & Beliefs

> "Understanding future teachers' beliefs as well as how their beliefs are related to teaching practices and motivation may allow teacher educators to plan instruction that will best support the development of teachers. These beliefs may also play a role in what pre-service and practicing teachers learn in their course work and professional development experiences" (Fives & Buehl, 2008, p. 172).

It is commonly accepted that students come into the majority of classrooms with existing personal beliefs systems about what will be taught, and these beliefs will in turn influence what they will learn. Research has shown students' existing belief systems are resilient to change, especially when using traditional teaching methods (Ambrose, 2004). Other studies verified this finding when they discovered that the beliefs teachers held did not always correspond with their teaching behaviors. They taught in ways that were inconsistent with their personal belief systems (Raymond, 1997; Vacc & Bright, 1999).

Citing a list of researchers including Bandura, Pajares (1992) sees the examination of beliefs as the "best indicators of the decisions individuals make throughout their lives" (p. 136). Beliefs influence behaviors, and guide the course of action an individual takes. There are different types of beliefs, and of interest to this study are self-efficacy beliefs, individual belief systems , and knowledge as it relate to mathematics and the teaching of mathematics. Beliefs are judgments or opinions people hold. Self-efficacy is a type of self-belief like self-determination and self-concept. Knowledge is also falls under the umbrella of beliefs, in that knowledge is considered by some to be type of a justified or verified belief.

"The result is a view of belief that speaks to an individual's judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do. The challenge is to assess each component so as to have confidence that the belief inferred is a reasonably accurate representation of that judgment" (Pajares, 1992, p. 316). In reviews of the research literature, De Corte, Verschaffel, and Depaepe (2008) found that despite students' education levels, they hold "naïve, incorrect, and/or negative beliefs about mathematics as a domain and about mathematics learning and teaching. Moreover there is evidence that the prevailing teaching practices and the culture in mathematics classrooms are largely responsible for the development in students of those nonavailing beliefs" (p. 34).

Self-efficacy & Knowledge

According to Bandura's theory of self-efficacy, one of its four sources is mastery experience. Mastery experience involves personal learning experiences, includes the acquisition of knowledge and skills. It makes sense that teachers' knowledge of math and teaching math would contribute to their self-efficacy beliefs for doing math, teaching, and teaching math. The research on teachers' mathematics content and pedagogical content knowledge to date has shown that the majority of elementary and middle school teachers do not have adequate levels, depths, and breadth of mathematics knowledge needed to be effective math teachers. One study compares the breadth and depth of teachers' mathematical knowledge by comparing the to popular taxonomies. They showed that the mathematics knowledge teachers possess is relegated to the lower levels of thinking and is limited to rote and procedural knowledge (Holmes, 2012).

Courses on how to teach elementary mathematics courses oftentimes merely teach the elementary math content, instead of having their students learn about children's mathematics thinking and explicitly addressing their personal belief systems about mathematics.

Additionally, the Conference Board of the Mathematical Sciences, the National Council of Teachers of Mathematics and the National Council on Teacher Quality recommend that PSTs take 9 credit hours in mathematics courses specifically designed for teachers, yet the majority of institutions of higher education are not meeting the recommendations (Masingila et al., 2012).

Some of the issues involved in increasing the quality of teachers' mathematics knowledge are the same issues their students suffer from. Students with low self-efficacy beliefs for learning math and maladaptive personal belief systems about math have proven to be particularly challenging to teach. While they can demonstrate their acquisition of knowledge in class, their self-efficacy beliefs and personal belief systems have the tendency to remain unchanged, even when what is learned conflicts with their existing schema. Students have a tendency to compartmentalize the conflicting information in order to preserve their existing cognitive structures.

A quasi-experimental study of the different types of knowledge teachers are taught in the teacher education courses found that the types of knowledge teachers learned were related to the content of their course on teaching mathematics (Copur-Gencturk & Lubienski, 2013). The study used two measures of mathematics content and pedagogical content knowledge, the Diagnostic Teacher Assessments for Mathematics and Science (DTAMS) and the Mathematical Knowledge for Teaching (MKT) assessment. Both instruments have shown to be valid and reliable measures of the various types of math knowledge and pedagogies needed to teach math. The study divided the participants into two groups and exposed them to two different types of teaching mathematics courses. The first course was a more traditional course focusing on math content knowledge. The second course was a hybrid course including both math content and pedagogy. The study found that the pre-service teachers in the hybrid course had the biggest gains in knowledge (Copur-Gencturk & Lubienski, 2013). The study found that the math knowledge necessary for effective mathematics teaching is different than the math knowledge used in daily living (Copur-Gencturk & Lubienski, 2013). Their findings support the call for teacher education programs and courses designed for math teachers to aim to increase PSTs math content knowledge as well as their pedagogical math content knowledge. Their findings also support the growing trend in the use of the term “mathematical knowledge for teaching” to describe a construct consisting of a unique combination of different types of knowledge necessary to effectively teach mathematics.

A study in Germany used to the various components of teachers’ knowledge to predict instructional quality and students’ achievement (Baumert et al., 2010). They hypothesized that content knowledge (CK) and pedagogical content knowledge (PCK) are distinct constructs, that pedagogical content knowledge predicts instructional quality, and the effects on students’ outcome are mediated by instructional quality. Results indicate that CK and PCK are distinct constructs, and that the CK and PCK of teachers differed based on the type of teacher education program they were in. In Germany schools use a track system in schools are either on an academic track or a non-academic track. Teachers’ certifications are also either of an academic or non-academic track. They found that teachers educated and certified in the academic tract had higher CK and PCK than teachers from the non-academic track. However, when CK was controlled, teachers with the non-academic track 2 certification outscored the teachers from the academic track 1 in their PCK. It was surmised that this was due to a larger number of teaching methodology courses taught in the non-academic track 2 schools, and a more academically rigorous and demanding mathematics curriculum in the track 1 schools. They found that between schools, teachers' PCK accounted for 39% of the variability in students' achievement. Teachers' pedagogical content knowledge is a key factor in predicting students' math achievement, while acknowledging that the development of PCK requires CK (Baumert et al., 2010).

Self-efficacy, Gender and Ethnicity

Another facet of the Usher et al. (2008) review of sources of self-efficacy research included a section on studies examining group differences in self-efficacy and its sources based on gender and ethnicity. So far there are conflicting findings in regards to gender, with some studies finding no gender differences while others conclude they exist. They cite multiple studies which found consistent gender differences in self-efficacy in terms of the sources social persuasion and vicarious experience. They surmise it is possible female and male students form their self-efficacy beliefs from differing sources depending on academic domains and other factors. Female students tend to incorporate social persuasions and vicarious experiences in their formation of self-efficacy whereas male students find the modeling and feedback informative but not influential in the formation of their self-efficacy (Usher et al., 2008).

Their review also found evidence of several studies showing group differences in self-efficacy beliefs based on ethnicity and different cultures (Klassen, 2004b; Stevens et al., 2006; Stevens et al., 2004). In a review of cross-cultural self-efficacy research Klassen (2004b) found that efficacy beliefs in Western cultures operate differently than those in non-Western cultures, particularly collectivist cultures. In a separate study, Klassen (2004a) found different prediction models for self-efficacy beliefs for two different cultural groups in

Canada. Another study conducted in the Southwestern United States examined Caucasian and Hispanic high school students on a variety of mathematics related variables(Stevens et al., 2004). The researchers were testing the fit of a path model designed to predict the number of additional math courses the students were planning on taking as predicted by ability, prior mathematics achievement, mathematics performance, mathematics self-efficacy, and motivational orientation. They found the Caucasian and Hispanic students differed in how they formed their self-efficacy beliefs and other mathematics related outcomes (Stevens et al., 2004). In sum, more research on the existence of group differences in the formation of self-efficacy beliefs based on gender, ethnicity and culture are warranted.

Research Questions

The purpose of this study is to gain a better understanding of the complex relationships involved in the formation of a pre-service teachers' self-efficacy beliefs about teaching mathematics, in relation to two less specific self-efficacy beliefs teaching and doing math, and their personal belief systems and math performance knowledge for math and teaching math. It also seeks to understand how PSTs' personal characteristics and choices influence their self-efficacy beliefs, personal belief systems, and performance knowledge. The study seeks to answer the following research questions:

1) Do self-efficacy for teaching and self-efficacy for doing mathematics predict self-efficacy for teaching mathematics? Is one more predictive than the other? Does each type of self-efficacy belief offer a unique contribution, or can the more general measures of self-efficacy be used in lieu of the more domain and content specific self-efficacy for teaching mathematics?

2) Do self-efficacy beliefs about doing math and teaching, personal belief systems and performance knowledge about math and teaching math predict self-efficacy for teaching mathematics?

3) Do personal characteristics, self-efficacy beliefs for doing math and teaching, personal belief systems and performance knowledge of math and teaching math predict self-efficacy for teaching mathematics?

4) Are there group differences in pre-service teachers' self-efficacy beliefs for doing math and teaching, personal belief systems and performance knowledge of math and teaching math based on their personal characteristics and choices?

5) Does group membership change the prediction model for pre-service teachers' self-efficacy for teaching mathematics based on their self-efficacy beliefs about teaching and doing math, personal belief systems and performance knowledge of math and teaching math?

CHAPTER 3

METHODOLOGY

The following chapter discusses the population being sampled, sampling method, measures, and statistical analyses.

Participants

The participants are pre-service teachers and educators enrolled in a large university in the Southwestern United States. During the 2013-2014 academic year, the University had an enrollment of 29,0333, of which 22,773 were undergraduates. The average undergraduate student age in 2012 was 24.2 years of age, with a median age of 21.6 years, reflecting a larger population of non-traditional students and a larger percentage of part-time students (23.2%) than most research universities of a similar size. The gender and ethnic makeup of the University’s undergraduate student population in 2012 was: 55.7% women, 44.3% men; 43% Hispanic/Latino, 38.3% White, 6.4% American Indian or Alaskan Native, 3.3% Asian/Native Hawaiian/Pacific Islander, 2.7% Black or African-American, 2.8% two or more races, and 2.7% other/unknown. The University’s undergraduate student population is reflective of the demographics of the geographical and cultural Southwestern United States, where oftentimes Hispanics are the majority population and Spanish is the predominant native language.

The participants were acquired using convenience sampling. The criterion for inclusion was enrollment in one of two undergraduate courses in the College of Education’s Educational Psychology program: “Human Growth and Development (EDPY 303)” or “Learning in the Classroom (EDPY 310)”. Students enrolled in either EDPY 303 or EDPY 310 during the Spring 2014 semester were required, as part of their course responsibilities, to complete a research component. The research component involved two choices: either selecting, reading, and reviewing an educational research article or serving as a participant in an educational research study. During the Spring 2014 semester, there were 183 students enrolled in each EDPY course, for a total of 366 possible participants.

Measures

The participants completed a total of eight instruments and a demographic questionnaire. To measure the various self-efficacy constructs, four instruments were used: Teachers' Sense of Efficacy Scale (TSES) (Tschannen-Moran & Woolfolk Hoy, 2001), Self-efficacy for Teaching Mathematics Instrument (SETMI) (McGee, 2010), and Self-efficacy for Doing Mathematics (SEDM). To measure teaching math beliefs and beliefs about math, two instruments were used: the TEACH MATH Beliefs Survey (TM Beliefs) (Aguirre et al, 2010) , and Beliefs About Mathematics (M Beliefs). To measure the different types of mathematics related knowledge needed for teaching mathematics, two instruments were used: Diagnostic Teacher Assessment for Mathematics and Science (DTAMS) by University of Louisville Center for Research in Mathematics and Science Teacher Development (CRMSTD), and the Mathematical Knowledge for Teaching (MKT) (Hill, Schilling, & Ball, 2004).

Demographic Questionnaire

The demographic variables included in the analyses are the participants': age, gender, ethnicity, target teaching level, teaching focus, year in school, information about their school or college and major, background in mathematics education, and plans for further math education. See Appendix A.

Self-efficacy Measures

Teachers Sense of Efficacy Scale (TSES)

Researchers Tschannen-Moran &Woolfolk Hoy (2001) created the TSES to address the validity and reliability issues of other instruments used to measure teachers' self-efficacy (Dellinger et al., 2008; Klassen et al., 2011; Labone, 2004; Morris & Usher, 2011; Tschannen-Moran & Woolfolk Hoy, 2001). The TSES is available in two forms. There is a short form version consisting of 12 items and a long form consisting of 24 items. Both versions have three subscales: Efficacy in Student Engagement, Efficacy in Instructional Practices, and Efficacy in Classroom Management. The authors recommend using the long form and conducting a factor analysis to see if the items load on to one or three factors, when the participants are pre-service teachers (Tschannen-Moran & Woolfolk Hoy, 2007). Studies with pre-service teachers have found the items generally load onto a single factor (Duffin et al., 2012; Fives et al., 2007). The long form will be utilized as recommended since the current study will be using pre-service teachers (Duffin et al., 2012; Fives & Buehl, 2009) and all findings to date using PSTs confirm the single factor model. The one study with findings contrary to this trend used a sample of PSTs whom had already completed their student teaching requirements

The original TSES uses a 9-point Likert scale with values ranging from 1-9, with "1 = Nothing", "3 = Very Little", "5 = Some Influence", "7 = Quite a bit", "9 = A Great Deal". The participants are presented the framing question, "How much can you do?" before they proceed to read and respond to the various items. The items are written in the form of a question, each which asks "How much can you …?" do a variety of "things that create difficulties for teachers in their school activities". An example of one of the items is, "How much can you do to motivate students who show low interest in schoolwork?" (Tschannen-Moran & Woolfolk Hoy, 2001).

Two design modifications are made to the TSES. First, all the items written as questions will be transformed into statements in line with all of self-efficacy instruments Bandura created and included in the appendix of "Guide to Constructing Self-efficacy Scales" (Bandura, 2006). Additionally, by converting the questions to statements, it will provide a level of consistency between surveys, by aligning the TSES with the format of the other surveys to be used in this study.

Second, instead of the 9-point Likert scale for the responses, the participants will be asked, "*How certain are you that you can successfully do each of the following things. Please rate from 0% to 100% certain.*" Bandura recommends using a confidence scale from 0-100 instead of a Likert scale in his "Guide to Constructing Self-efficacy Scales"(2006). Additionally, Fives and Buehl (2009) recommend using 0-100 scales when administering the TSES to pre-service teachers. The probability increases that there will be more variability in the pre-service teachers' responses by increasing the range of responses from a 5-point Likert scale to a 0-100 scale (Pajares et al., 2001). No studies reviewed were found to have used the suggested modified response scale of 0-100 in studies utilizing the TSES.

With the potential for increased variability, there is a slight possibility the 3-factor solution would achieve a better fit than the 1-factor model. However, this is not supported by the literature. It is possible that with their limited teaching experience and classroom exposure, PSTs are not experienced enough to distinguish between the various facets of their self-efficacy for teaching. Pre-service teachers will likely confirm a single factor structure (Duffin et al., 2012). The TSES measured the variable "self-efficacy for teaching" (SET), with a reported alpha level of $\alpha = .96$ and .97 for the single factor structure (Duffin et al., 2012).See Appendix B.

Self-efficacy for Teaching Mathematics Instrument (SETMI)

Self-efficacy for Teaching Mathematics Instrument (SETMI) was created by McGee in 2012 in response to the need for a new instrument measuring self-efficacy for teaching mathematics which is both reliable and valid, as well as based on Bandura's social cognitive theory (McGee & Wang, 2014). Existing instruments are problematic for a variety of reasons, most troubling is the lack of theoretical validity. For a complete list and summary of the existing self-efficacy instruments from the past 30 years, see McGee & Wang (2014, table 1, p. 3).

The SETMI was created from the existing framework of Tschannen-Moran & Woolfolk Hoy's (2001) Teacher's Sense of Efficacy Scale (TSES). The TSES has been extensively researched and has proven to be both a reliable and valid measure of self-efficacy for teaching (Bandura, 2006; Duffin et al., 2012; Fives & Buehl, 2009; Klassen et al., 2011; Morris & Usher, 2011; Tschannen-Moran & Woolfolk Hoy, 2001, 2007; Woolfolk Hoy & Spero, 2005). In adapting the McGee modified TSES instrument for use with content and level-specific items for teaching elementary mathematics.

Like with the TSES above, two design modifications were made to the SETMI. The changes were made to make the scales more effective and to maintain consistency between surveys used in the study. Consistent with Bandura's recommendations (Bandura, 2006), all of the items initially written as questions were transformed into statements. As with the TSES, instead of the original 5-point Likert response scale, participants were asked to respond to an answer stem, "*How certain are you that you can successfully do each of the* *following things. Please rate from 0% to 100% certain."* Fives and Buehl (2009) suggested using 0-100 scales with the TSES and pre-service teachers, and it follows that the same would hold true for the SETMI. By increasing the possible range of responses from a 5-point Likert scale to a 0-100 scale, the probability increases there will be more variability in the pre-service teachers responses improving the psychometric properties of the instrument (Pajares et al., 2001). Contrary to the current research on the 3-factor structure of the TSES, the STEMI consists of only 2 factors, and the 2-factor structure has been confirmed when measured with PSTs and in-service teachers (Charalambous, Philippou, & Kyriakides, 2008; McGee & Wang, 2014).

Similar to another study, the TSES was adapted to be more content specific in order to use it to measure self-efficacy beliefs for teaching math. During the creation of the SETMI, it was discovered that two items were highly correlated and cross-loading onto both factors. Researchers of both instruments dropped the items and as a result found a stable 2-factor structure during their exploratory factory analyses (Charalambous et al., 2008; McGee & Wang, 2014). The resulting SETMI consists of 22-items and has 2 sub-scales. The 7-item Efficacy for Pedagogy in Mathematics (EPM), with a reported alpha level of $\alpha = .86$, and the 15-item Efficacy for Teaching Mathematics Content (ETMC), with a reported alpha level of $\alpha = .93$. Similar to the TSES above, however, since the SETMI was administered to pre-service teachers a single factor model was assumed. The participants' mean score off all SETMI items was used as the factor "self-efficacy for teaching mathematics" (SETM). See Appendix C.

Self-efficacy for Doing Mathematics (SEDM)

The Self-efficacy for Doing Math (SEDM) is a 26-item instrument created for this study by combining items from several federally funded assessment projects. Each of the assessment projects were funded to develop measures and/or item banks related to a multitude of factors related to the teaching and learning of math. The SEDM was created by using items developed by other projects. The following assessment projects from which the SEDM items originate were created as a result of the projects funding from the National Science Foundation (NSF). The Math and Science Partnership – Motivation Assessment Program (MSP-MAP) (S. A. Karabenick & Maehr, 2003-2009), Integrating Mathematics and Pedagogy (IMAP) (R. A. Philipp & Sowder, 2002) and Surveys of Enacted Curriculum (SEC) (Blank & Smithson, 2001) were utilized to create the SEDM instrument. Several original items were also written for and included in this study. Consistent with the formats of the TSES and the SETMI, the participants were asked to respond to the items based on the answer stem, "How certain are you that you can successfully do each of the following things. Please rate from 0% to 100% certain." See Appendix D for a list of all survey items, means, and standard deviations. The participants' mean score for all SEDM items was used for the factor "self-efficacy for doing mathematics". See Appendix D.

Beliefs Measures

Teachers Empowered to Advance Change Math Beliefs Survey

Teachers Empowered to Advance Change in Math Beliefs Survey (TM Beliefs) was created from selected items from the NSF sponsored, multi-institutional, Teachers Empowered to Advance Change in Math (TEACH MATH) grant. The TM Beliefs survey used in this study consists of a selection 15 items from their larger survey. The chosen items are designed to assess teachers' beliefs about teaching math and children's' mathematical thinking. Participants are asked to respond to each item using the answer stem "How much do you believe each of the following statements? Please rate from 0% to 100% believe." Like the instruments detailed above, the survey was modified to use a 0-100 response scale to increase to potential variability of responses and maintain consistency between surveys administered during the study. The participants' mean score for all TM Beliefs items was used for the factor "beliefs about teaching math". See Appendix E.

Beliefs About Mathematics (BAM)

The Beliefs About Math instrument was created by combining items taken from two assessment projects and from the research literature on misconceptions about mathematics (Allen, 2007). The BAM instrument consists of 25-items and was created by combining items from two grants funded by the National Science Foundation (NSF). The Math and Science Partnership – Motivation Assessment Program (MSP-MAP) and Integrating Mathematics and Pedagogy (IMAP) projects developed items related to beliefs about mathematics, and the relevant items were selected for the BAM instrument. For each item, the participants were asked, "How much do you believe each of the following statements? Please rate from 0% to 100% believe." The survey was modified to use a 0-100 response scale to increase to potential variability of responses and maintain consistency between surveys administered during the study. The participants' mean score for all BAM items was used for the factor "beliefs about teaching math". See Appendix F

Knowledge Measures

Math Content Knowledge

In order to measure the participants' math content knowledge, the Diagnostic Teacher Assessments for Mathematics and Science (DTAMS) were selected based on the instruments strong showing in the research literature and the needs of this study. The DTAMS assessments were designed by a group of multidisciplinary development teams at the University of Louisville's Center for Research in Mathematics and Science Teacher Development (CRMSTD) in order to determine breadth of appropriate and assessable mathematics content for elementary and middle school teachers of mathematics (Bush, 2005).

They accomplished this by using a team of mathematicians, mathematics educators and middle and elementary school math teachers. They developed prototype and parallel assessment forms by first creating "Mathematics Summary Charts" for both the middle school and elementary level assessments (Bush, 2005). The DTMAS assessments for mathematics at both school levels contain items in alignment with the standards of the Conference Board of the Mathematical Sciences (CBMS), Educational Testing Services (PRAXIS), National Council of Teachers of Mathematics Professional Standards for Teaching Mathematics (NCTM-PTS), and other respected institutions. As a result the items have construct validity and are reflective of the math elementary level teachers teach.

The DTAMS were constructed to assess a various aspect of mathematical knowledge necessary to be an effective mathematics teacher. The DTAMS assessments measure four types of mathematical knowledge: Type I – Rote Memory; Type II – Conceptual Knowledge, Type III – Problem Solving/Reasoning; and Type IV – Mathematics Knowledge for Teaching (Saderholm et al., 2010). There are two level of the DTAMS assessments; elementary and middle school. Each level of the DTAMS is comprised of four assessments, each of which measure between 1-3 math content areas. The four DTAMS assessments designed for elementary school teachers assess a total of seven math content areas: rational numbers, geometry, measurement, probability, statistics, algebra and whole number computation.

Each DTAMS assessment form has 20 items: 10 multiple choice and 10 open-ended items. The multiple choice items 1-10 measure the first two types of knowledge, items 11-15 measure problem/solving and reasoning, and 16-20 measure pedagogical content knowledge. Due to participant time limitations and the qualitative nature of the type III & IV knowledge items, the DTAMS was only used to assess the first two types of knowledge: rote memory (I) and conceptual knowledge (II). Five items from each content area assessment assessing knowledge types I and II were selected for use in this study, for a total of 20-items (Table 2). The participants' total scores were computed and the score for percent correct was used for the factor "math content knowledge". The percent score was used for ease of interpretation as well as retain a consistent use of a response scale ranging from 0-100. See Appendix G.

Table 1. DTAMS Elementary Math Items by Knowledge Type and Content Area

	Geometry & Measurement (GM)	Probability, Statistics & Algebra (PSA)	Whole Number Computation (WNC)	Rational Numbers (RSC)
Type I. Rote Memory	4, 15	3, 9, 13	8, 12	2, 10
Type II. Conceptual Knowledge	7, 11, 17	5, 6, 19	1, 16	14, 18, 20

Mathematical Knowledge for Teaching

The Learning Mathematics for Teaching assessment project designed assessments to measure the mathematical knowledge required to teach math, or what the researchers have identified as mathematical knowledge for teaching (MKT). MKT is a specialized set of knowledge including pedagogical content knowledge required to effectively teach mathematics (Ball et al., 2005).

The MKT assessments include four content areas (numbers and operations, geometry, algebra, statistics and probability), two grade levels (elementary, middle school) and are the result of extensive research, expertise, and psychometric testing.

The MKT's terms of use, participants' total scores are prohibited from being used or reported. Instead the total scores must be converted using Item Response Theory (IRT) by using the provided table of converted scores, which differ according to the number of items in the assessment. Using the table provided, the total scores are converted based on the participants' number of correct responses. The transformed MKT total scores have a range of -2.0 to 2.0, with 2.0 representing a perfect score and -2.0 no correct answers.

The rationale behind prohibiting the use and publication of total scores is to protect teachers and prevent school districts from using the assessments as an measure of teachers' knowledge and ability to teach math. The LMT project is adamant the MKT not be used to evaluate teachers and compare them against one another. The scores are not to be used to evaluate levels of teachers' mathematical knowledge. Thus the designers of the MKT reasoned that by converting the total scores using IRT, it would protect the participants from being assessed and judged unfairly. The MKT's strict guidelines and terms of use work to increase the probability that their items will be novel to the participants, decreases the chance the items (and answers) can be found in an online search, increases the likelihood the assessments will be administered and scored correctly, and maintains the MKT assessments' sound psychometric properties.

For the purposes of this study, only the 2004 Elementary Number and Operations MKT assessment form A was utilized. This assessment consisted of a total of 14 items, however, several items share a question stem and have multiple scenarios to respond to. In total, there are 26 items, 10 traditional multiple-choice and16 containing sub-parts. All items have an "I'm not sure" response option, which was justified by the likelihood it would increase the overall response rate and improve the quality/accuracy of responses by decreasing instances of random guessing and the number of missing responses. Participants' total scores were calculated and then converted. See Appendix H

Procedure

A secure web-based survey administration program, Surveymonkey™, was utilized to host and administer the surveys. Professors and instructors for the Educational Psychology courses from which the participant pool originate were notified via email that they study was open and available for their students to complete, and were additionally sent an email to forward to their students. The email contained a description of the study and a link to participate via the Educational Psychology participant pool website. The surveys were administered on-line using a secure web-based survey program, Surveymonkey™, and were accessed through a link hosted on the educational psychology participant pool website. The study was online and available for the participants to complete for a total of seven weeks, one of which was spring break.

After clicking on the link to the study, a consent form to participate in anonymous online research survey appeared. Before being allowed to proceed onto the study, the participants had to first indicate their consent to participate by clicking "I agree to participate" after reading the on-line consent form. . If they choose not to participate, and clicked "I decline to participate" the survey closed. For those consenting to participate, the study began by administering the first of the 8 instruments. The participants were allowed to complete the survey throughout data collection period so long as they kept the browser window with the study open. If the study remained open in their browser window, they could take as much time to complete the survey in as many sessions as they desired. The participants were told the study would not take longer than two hours to complete. Two emails were sent to remind them of the study and their opportunity to participate.

In order to receive the course research credit for their participation in the educational research, at the conclusion of the study the participants were redirected to complete a research participation debriefing form designed and provided by the Educational Psychology program. The debriefing form only opened after the participants clicked “finish” at the conclusion of the study, whereupon the study webpage closed and the debriefing form opened. At the conclusion of the data collection period, the participants’ debriefing form responses were emailed to their course professors in a .pdf document to document their participation so they received research credit.

The first instrument was the self-efficacy for teaching mathematics instrument (SETMI), then the teachers’ sense of efficacy scale (TSES). There were eight instruments, six of which used the same 0-100 scale, so fatigue and monotony were concern. For this reason, it was decided to intersperse the demographic questions throughout the entire survey, as opposed to asking them all at one time. Additionally, the two different math assessments were of concern in that they could, and most likely would, cause some participants to drop out. The possible reason for their dropping out include that they may not have had plans to ever teach or have anything to do with math. To help protect against attrition, the math content assessment (DTAMS) was broken up into four 5-question sections and were spaced throughout the study. Two sections were before the mathematics for teaching (MKT) assessment and two appeared after. The self-efficacy for doing math (SEDM) instrument was the third to appear, and consistent with theory, it was placed prior to any math performance assessment. Then came mathematics knowledge for teaching (MKT), followed by beliefs abut math and beliefs about teaching math. The study concluded with a series of demographic items.

Analyses

A standard multiple regression was used to answer research question, which examined if self-efficacy for teaching, self-efficacy for doing mathematics, beliefs about teaching mathematics, beliefs about mathematics, mathematical content knowledge, and mathematical knowledge for teaching predict self-efficacy for teaching mathematics? Self-efficacy for teaching mathematics (SETMI) is the dependent variable. The independent variables are self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT).

Research question 2 examined if self-efficacy for teaching and self-efficacy for doing mathematics predict self-efficacy for teaching mathematics? Is one more predictive than the other? A standard multiple regression was used with self-efficacy for teaching mathematics (SETM) as the response variable and self-efficacy for teaching (), self-efficacy for doing mathematics (SEDM) as the predictor variables.

Research question 3 examined if there is a difference in self-efficacy for teaching mathematics, self-efficacy for teaching, self-efficacy for doing mathematics, beliefs about teaching mathematics, beliefs about mathematics, mathematical content knowledge, and mathematical knowledge for teaching based on gender, ethnicity, teaching focus, and/or teaching level. A MANOVA will be used to assess if there are any multivariate effects, as well as univariate effects for each independent variable. The predictor variables were gender, ethnicity (Hispanic, non-Hispanic), teaching focus (STEM, non-STEM), and/or teaching level (EC/Elementary, Secondary, Other/non-Educator). The response variables were self-efficacy for teaching mathematics (SETM), self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (MB), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT). Post-hoc analyses using Tukey's HSD will be run for teaching license.

Research question 4 examined differences in pre-service teachers' self-efficacies, personal belief systems, and math performance knowledge based on their group membership. Using a standard multiple regression (enter) analysis self-efficacy for teaching mathematics (SETMI) was the dependent variable, and the independent variables were: age, gender, ethnicity, teaching focus, teaching license, self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT).

Research question 5 and its subparts examines whether or not the prediction model for self-efficacy for teaching mathematics changes as a result of PSTs group membership(s). Multiple regression analyses were run for the groups in which a there was a statistically significant difference found during the MANOVA analysis in research question 4. The analyses will only be run with the groups found to have statistically significant multivariate differences in their self-efficacy, personal beliefs systems, and performance knowledge. Regression analyses could be run for the groups with dichotomous group: gender (male, female), ethnicity (Hispanics, non-Hispanic), teaching license (PST, non-PST), and teaching focus (STEM, non-STEM). Separate analyses were used based on PSTs group membership using the same variables from research question 2. The response variable was self-efficacy for teaching mathematics (SETMI) and the predictor variables were self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and pedagogical content knowledge for mathematics (MKT).

Summary

This study examines the complex relationships involved in the formation of PSTs' self-efficacy for teaching mathematics. Seven measurements and one demographic questionnaire were administered online to 184 pre-service teachers acquired via convenience sampling at a large university in the Southwestern United Stated. In six out of seven cases, the participants' mean score for all items was used to measure the factor of interest. Seeking to understanding as to if and how less specific self-efficacy beliefs are related to and predictive of the more domain specific SETMI, standard multiple regression analyses were used. The information gathered from the battery of assessments was analyzed via a series of multiple regression analyses to understand how PSTs' self-efficacy beliefs, personal belief systems as well as their math content knowledge and mathematical knowledge for teaching are related to and predictive of SETMI. Additionally a MANOVA was run to determine the presence of any multivariate effects based on the PSTs' personal characteristics or choices. Based on the discovery of any statistically significant group differences, an additional set of multiple regression analyses were run to determine if the prediction models differed by groups.

CHAPTER 4

RESULTS

A total of 212 students participated in the research study for a 57.9% participation rate. The participation rate most likely would have been higher had the study been opened earlier in the semester and remained open for a longer period of time. The study opened on the last day of class before spring break, and remained open for 5 weeks. Even with the short data collection period, the goal of enrolling a minimum total of 160-200 participants was reached.

A total of 13 cases (6.1%) were deleted due to a high number of missing responses on two instruments (DTAMS, MKT). Using descriptive statistics, time to complete survey, and Mahalanobis' distance, a total of seven outliers (3.3%) and six other (2.8%) cases were found and deleted. The final dataset used for all analyses consisted of 184 participants (N = 184).

Characteristics of Current Sample

The average student age was 26 years old (median = 22 years), with the majority of students in their junior (41.8%) or senior (35.2%) years. Of the remaining participants, 19.2% were sophomores, 2.2% freshmen, and 1.6% post-bachelor or graduate students. There were more women (76.8%) than men (23.2%), more Early Childhood and Elementary (54.3%) educators than Secondary (23.4%), and other/non-educators (22.3%) The sample's ethnic make-up was 43.5% White, 45.1% Hispanic, 6% American Indian, 2.7% Asian, and 2.7% Other (one participant identified as "American"). This was consistent with the university's larger student demographic population.

All students choosing to participate in the study were given the measures regardless of their targeted teaching specialization or field. Of the 184 participants, when asked what teaching license they were working to obtain: 8.2% said early childhood (EC), 46.4% elementary, 4.4% middle school, 19.1% high school, 1.6% K-12, 8.1% other educator, 12.0% reported none, and 0.5% were missing. The data were re-categorized into three groups: EC/elementary (54.6%), secondary (25.1%), and other/non-educator (20.1%). The participants' future teaching endorsement area were 35.3% STEM, 39.1% non-STEM, and 25.5% reported none. Since many college students have yet to decide their future career paths, another characteristic, "teaching focus", which is a subject in which the participants will have taken at least 24 credit hours, was examined as a dichotomous variable, with 52.2% of participants having a STEM based focus and 47.8% a non-STEM based focus.

In terms of prior mathematics education, the participants reported taking an average of four math classes in high school, $M = 3.91$, $SD = 1.37$, and reported completing an average of three math courses up to this point in their college educations, $M = 3.33$, $SD = 1.80$. Based on their current reported math course plans, they will complete an average total of four mathematics courses throughout their undergraduate educations, $M = 4.16$, $SD = 2.19$. It should be noted that some of the participants included remedial mathematics courses in their totals. For the purposes of this study, the types (content or methods) or level of mathematics courses were not analyzed.

RQ1: Self-efficacy Beliefs for Teaching and Doing Math

A standard multiple regression analysis was run to answer the first research question: do self-efficacy for teaching or self-efficacy for doing mathematics predict self-efficacy for teaching mathematics. The response variable was self-efficacy for teaching mathematics

(SETM). The predictor variables were self-efficacy for teaching (SET) and self-efficacy for doing mathematics (SEDM).

R for regression was significantly different from zero, *F* (2, 157) = 82.24, $p < .001$, with R^2 at .48. The adjusted R^2 value of .48 indicates that nearly half of the variability in self-efficacy for teaching mathematics is predicted by self-efficacy for teaching and self-efficacy for doing math. Both factors had statistically significant regression coefficients, with Self-efficacy for Doing Math $\beta = .53$, $p < .001$, $r = .55$ and Self-efficacy for Teaching $\beta = .28$, $p < .001$, $r = .33$ (Table 2).

Combined, 48% (48% adjusted) of the variance in self-efficacy for teaching mathematics was predicted by the two self-efficacy factors: self-efficacy for teaching and self-efficacy for doing math. The size and direction of the relationships suggests that a higher self-efficacy for teaching mathematics is indicative of a higher self-efficacy for doing math, as well as a higher self-efficacy for teaching. Of the two variables, self-efficacy for doing math had a stronger relationship with self-efficacy for teaching mathematics than did self-efficacy for teaching. Increasing self-efficacy in either teaching or doing math will increase self-efficacy for teaching math, however, self-efficacy for doing math has a stronger influence than self-efficacy for teaching. The self-efficacy for doing math was more predictive than self-efficacy for teaching. Both were predictive of self-efficacy for teaching mathematics.

Table 2. Standard Multiple Regression of Self-efficacy Variables on Self-efficacy for Teaching Mathematics

	1.	2.	3.	Means	*SD*	B	β	*r*
1. Self-efficacy for Teaching Math	1.00			82.74	11.20			
2. Self-efficacy for Teaching	.53*	1.00		85.31	9.39	**.33***	**.28***	.33
3. Self-efficacy for Doing Math	.67*	.46*	1.00	80.96	12.40	**.48***	**.53***	.55

*$p < .001$

RQ2: Self-efficacy, Personal Beliefs Systems and Knowledge

A standard multiple regression analysis was run to answer the second research question if self-efficacy for teaching, self-efficacy for doing mathematics, beliefs about teaching mathematics, beliefs about mathematics, mathematical content knowledge, and mathematical knowledge for teaching predict self-efficacy for teaching mathematics. The response variable was self-efficacy for teaching mathematics (SETM). The predictor variables were: self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT). Results of evaluation of assumptions led to the deletion of a total of 5 cases found to be outliers (four univariate, one multivariate). Using Mahalanobis distance $\chi 2$(df 6, p = .001) = 22.46, three additional cases were deleted from all further analyses.

Results showed *R* for regression was significantly different from zero, F (6, 170) = 40.61, $p < .001$, with R^2 at .59. The adjusted R^2 value of .58 indicates that nearly three fifths of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 4): Self-efficacy for Teaching, Self-efficacy for Doing Math, Beliefs about Teaching Math, and Math content knowledge. Neither math beliefs nor mathematical knowledge for teaching had statistically significant regression coefficients, even though all of their bivariate correlations are statistically significant with one exception (MKT and SE Teaching) (Table 3).

The model explains 59% (58% adjusted) of the variance in s' self-efficacy for teaching mathematics, with 4 of the 6 variables making statistically significant contributions. Of the four statistically significant variables, self-efficacy for doing math, $\beta = .38$, $t = 6.29$, $p < .001$, $r = .44$ and math content knowledge, $\beta = .37$, $t = 5.53$, $p < .001$, $r = .39$, were the strongest predictors, followed by self-efficacy for teaching, $\beta = .30$, $t = 5.21$, $p < .001$, $r = .37$ and beliefs about teaching math, $\beta = .22$, $t = 3.63$, $p = < .001$, $r = .27$. The size and direction of the relationship suggests that PSTs with a higher self-efficacy for teaching mathematics have a higher self-efficacy for doing math, better math content knowledge, a higher self-efficacy for teaching, and hold more progressive beliefs about teaching math. Beliefs about math and mathematical knowledge for teaching did not have statistically significant regression coefficients predicting self-efficacy for teaching mathematics, however, they did have statistically significant correlations with the other variables in the model.

Table 3. Correlations of Self-efficacy, Belief, and Knowledge Variables

	1.	2.	3.	4.	5.	6.	7.
1. SE Teaching Math	1.00						
2. SE Teaching	.51***	1.00					
3. SE Doing Math	.65***	.45***	1.00				
4. TM Beliefs	.25***	.26***	.14*	1.00			
5. Math Beliefs	.20**	.23**	.19**	.43***	1.00		
6. Math Content Knowledge	.37***	-.06	.29***	-.32***	-.13*	1.00	
7. MKT	.19**	-.10	.24***	-.37***	-.17*	.64***	1.00

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 4. Multiple Regression of Self-Efficacy, Belief, and Knowledge Variables on Self-efficacy for Teaching Mathematics

RQ1	Mean	Standard Deviation	B	*β*	*r*
Self-efficacy for Teaching Math	82.82	11.21	-9.29		
Self-efficacy Teaching	85.36	9.43	0.36	**0.30*****	0.37
Self-efficacy Doing Math	80.96	12.45	0.34	**0.38*****	0.44
Beliefs About Teaching Math	66.86	11.31	0.22	**0.22*****	0.27
Beliefs About Math	63.46	10.50	0.01	0.01	0.02
Math Content Knowledge	65.37	14.88	1.40	**0.37*****	0.39
Mathematical Knowledge for Teaching	-0.72	0.97	-0.38	-0.03	-0.04

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

RQ3: Self-efficacy, Personal Belief Systems, Knowledge and Demographic Characteristics

A standard multiple regression was run to answer the third research question: do age, gender, ethnicity, teaching license, and/or teaching level, in addition to self-efficacy for teaching, self-efficacy for doing mathematics, beliefs about teaching mathematics, beliefs about mathematics, mathematical content knowledge, and mathematical knowledge for teaching predict self-efficacy for teaching mathematics? The response variable was self-efficacy for teaching mathematics (SETM). The predictor variables were self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT), with the addition of demographic variables: age, gender, ethnicity (Hispanic, non-Hispanic), teaching focus (STEM, non-STEM), and teaching license (PST, non-PST).

Results showed *R* for regression was significantly different from zero, $F_{(11, 160)} = 24.22$, $p < .001$, with R^2 at .63. The adjusted R^2 value of .60 indicates that three fifths of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 5) self-efficacy for doing math, self-efficacy for teaching, beliefs about teaching math, math content knowledge, teaching focus, and teaching license. Age, gender, ethnicity, beliefs about math, and mathematical knowledge for teaching did not have statistically significant regression coefficients.

The model explains 63% (60% adjusted) of the variance in self-efficacy for teaching mathematics, with 6 of the 11 variables making statistically significant contributions. Of the five statistically significant variables, self-efficacy for doing math, $\beta = .37$, $p < .001$, $r = .42$, self-efficacy for teaching, $\beta = .32$, $p < .001$, $r = .39$ and math content knowledge, $\beta = .34$, $p < .001$, $r = .37$ were the strongest predictors, followed by beliefs about teaching math, $\beta = .23$, p = < .001, $r = .29$, teaching focus, $\beta = .12$, $p = .02$, $r = .18$, and teaching license, $\beta = -.12$, $p = .026$, $r = -.18$. The addition of the demographic variables to the model yielded two additional predictors: teaching focus (STEM, non-STEM) and teaching license (PST, non-PST).

The same factors that were statistically significant in the second model remained statistically significant in this third model. The addition of the demographic variables yielded only a slightly improved prediction model and only two demographic predictor variables, teaching focus (STEM, non-STEM) and teaching license (PST, non-PST, were predictive of self-efficacy for teaching mathematics. These findings are consistent with self-efficacy theory, in that they are the only demographic characteristics in which the PSTs have any personal agency over. Unlike gender and ethnicity, which are pre-determined, PSTs choose their teaching focus and teaching license. The only predictive demographic variables are the ones within the individual participant's locus of control. Individual characteristics assigned at birth (age, gender, ethnicity) are not predictive of self-efficacy for teaching mathematics.

Table 5. Multiple Regression of All Predictor Variables on Self-efficacy for Teaching Mathematics

RQ3 N = 172	Mean	Standard Deviation	B	*β*	*r*
Self-efficacy Teaching Math	82.90	11.22	-7.66		
Self-efficacy for Teaching	85.35	9.48	0.37	**0.32***	0.39
Self-efficacy Doing Math	81.25	12.24	0.34	**0.37***	0.42
Teach Math Beliefs	66.81	11.44	0.22	**0.23***	0.29
Math Beliefs	63.54	10.62	0.02	0.02	0.03
Math Content Knowledge	65.38	14.98	1.29	**0.34***	0.37
Mathematical Knowledge for Teaching	-0.73	0.98	-0.46	-0.04	-0.05
Age	25.85	9.19	-0.05	-0.04	-0.06
Gender	1.24	0.43	-1.97	-0.08	-0.12
Ethnicity	0.46	0.50	0.91	0.04	0.06
Teaching Focus	0.54	0.50	2.77	**0.12***	0.18
Teaching License	0.79	0.41	-3.25	**-0.12***	-0.18

*$p \leq .05$, **$p \leq .01$, ***$p \leq .001$

RQ4: Group Differences in Self-efficacy for Teaching Mathematics based on Demographic Characteristics

A four-way MANOVA was run to determine if there a difference in self-efficacy beliefs for teaching mathematics, teaching, and doing mathematics, personal belief systems beliefs about math and teaching math, math content knowledge, and mathematical knowledge for teaching based on PSTs' personal characteristics. The independent variables were: gender, ethnicity (Hispanic, non-Hispanic), teaching level (EC/Elementary, Secondary, Other Educator), and/or teaching focus (STEM, non-STEM). The dependent variables were: self-efficacy for teaching mathematics (SETM), self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK), and mathematical knowledge for teaching (MKT). The analysis revealed a significant multivariate main effect for ethnicity, Wilks' $\lambda = .87$, $F_{(7, 162)} = 3.47$, $p =. 002$, $_{\text{partial}}\eta^2 = .13$;

teaching focus, Wilks' λ = .85, $F_{(7, 162)}$ = 4.09, p <. 001, $_{partial}\eta^2$ = .15, and teaching license, Wilks' λ = .81, $F_{(7, 162)}$ = 2.48 p = . 002, $_{partial}\eta^2$ = .10.

Given the significance of the multivariate tests, the univariate main effects were examined (Table 7). Using an adjusted alpha level of .007, significant univariate main effects for ethnicity were obtained for mathematics content knowledge, $F_{(1, 168)}$ = 11.38, p < .001, $_{partial}\eta^2$=.06. Hispanic participants scored over 7.5 points lower on the assessment of mathematics content knowledge M = 61.17, SD = 14.86, compared to non-Hispanics M = 68.91, SD = 14.02.

For Teaching focus, significant effects were found for self-efficacy for teaching mathematics, , $F_{(1, 168)}$ = 7.77, p = .006 , $_{partial}\eta^2$=.04, math content knowledge, , $F_{(1, 168)}$ = 8.02, p = .005 , $_{partial}\eta^2$=.05, and mathematics knowledge for teaching, , $F_{(1, 168)}$ = 8.98, p <.003 , $_{partial}\eta^2$ =.05. Participants with a STEM focus had higher self-efficacy for teaching mathematics M = 84.39, SD = 11.37, mathematics content knowledge M = 67.84, SD = 14.62, and mathematical knowledge for teaching M = -0.55, SD = 0.96 compared to the non-STEM participants. Their lower scores were for self-efficacy for teaching math M = 80.99, SD = 10.8, math content knowledge M = 62.5, SD = 14.75, and mathematical knowledge for teaching M = -0.93, SD = 0.93.

For teaching level, significant effects were found for beliefs about mathematics, $F_{(1, 168)}$ = 5.68, p = .004 , $_{partial}\eta^2$ =.06, math content knowledge, $F_{(1, 168)}$ = 5.34, p = .004 , $_{partial}\eta^2$=.06, and mathematics knowledge for teaching, , $F_{(1, 168)}$ = 6.74, p = .002 , $_{partial}\eta^2$ =.07. Post-hoc test were run on teaching license using Tukey's HSD and the same adjusted alpha level of .007. Significant pairwise mean differences were obtained for: beliefs about mathematics between EC/Elementary PSTs (M = 61.1, SE = 1.28) and Other Educator/Non-

Educators, (*M* = 67.49, *SE* = 1.76); on math content knowledge between Secondary PSTs (*M* = 13.67, *SE* = .43); and Other Educator/Non-Educators, (*M* = 11.68, *SE* = .48); and on mathematics knowledge for teaching between Other Educator/Non-Educators (*M* = -1.17, *SE* = .16); and both EC/Elementary PSTs, (*M* = -.55, *SE* = .11), and Secondary PSTs, (*M* = -.54, *SE* = .14). As there were no statistically significant group differences between EC/Elementary and Secondary PSTs, the tri-level Teaching License variable was recoded into a dichotomous group: PSTs and non-PSTs. All future analyses will be run using the newly created dichotomous teaching license (PST, non-PST) variable.

Table 6. Pooled Within-Cell Correlations Among Self-efficacy, Beliefs, and Knowledge Variables with Standard Deviations on the Diagonal

	1.	2.	3.	4.	5.	6.	7.
1. Self-efficacy for Teaching Math	11.13						
2. Self-efficacy for Teaching	.55	9.39					
3. Self-efficacy for Doing Math	.64	.48	12.33				
4. Beliefs About Teaching Math	.30	.26	.15	11.25			
5. Beliefs About Math	.23	.23	.19	.40	10.41		
6. Math Content Knowledge	.33	-.05	.28	-.27	-.07	2.99	
7. Mathematical knowledge for teaching	.13	-.08	.21	-.33	-.11	.60	.96

Table 7. Univariate Analysis of Variances of Self-efficacy, Beliefs, and Knowledge Variables by Gender, Ethnicity, Teaching Focus and Teaching License

	Sum of Squares	Mean Square	*F*	Partial η^2	Observed Power
Effects of DVs by Gender, df = (1, 168)					
Self-efficacy Teaching Math	240.58	240.58	2.05	.012	.30
Self-efficacy Teaching	55.34	55.34	0.62	.004	.12
Self-efficacy Doing Math	97.82	97.82	0.66	.004	.13
Teaching Math Beliefs	0.08	0.08	.001		.05
Beliefs About Math	17.63	17.63	0.17	.000	.07
Math Content Knowledge	0.36	0.36	0.05	.001	.06
Mathematical Knowledge for Teaching	2.00	2.00	2.41	.014	.34
Effects of DVs by Ethnicity, df = (1, 168)					
Self-efficacy Teaching Math	77.26	77.26	.65	.004	.13
Self-efficacy Teaching	13.30	13.30	.15	.001	.07
Self-efficacy Doing Math	461.57	461.57	3.13	.018	.42
Teaching Math Beliefs	455.82	455.82	3.64	.021	.48
Beliefs About Math	502.38	502.38	4.79	.028	.59
Math Content Knowledge	87.34	87.34	**11.38****	.063	.92
Mathematical Knowledge for Teaching	3.27	3.27	3.94	.023	.51
Effects of DVs by Teaching Focus, df = (1, 168)					
Self-efficacy Teaching Math	915.24	915.24	**7.79***	.044	.79
Self-efficacy Teaching	293.56	293.56	3.30	.019	.44
Self-efficacy Doing Math	851.61	851.61	5.78	.033	.67
Teaching Math Beliefs	35.80	35.80	.29	.002	.08
Beliefs About Math	8.96	8.96	.09	.001	.06
Math Content Knowledge	61.52	61.52	**8.02***	.046	.80
Mathematical Knowledge for Teaching	7.45	7.45	**8.98***	.051	.85
Effects of DVs by Teaching License df (2, 168)					
Self-efficacy Teaching Math	1028.66	514.33	4.38	.050	.75
Self-efficacy Teaching	99.18	49.59	.56	.007	.14
Self-efficacy Doing Math	233.64	116.82	.79	.009	.18
Teaching Math Beliefs	848.25	424.12	3.39	.039	.63
Beliefs About Math	1191.38	595.69	**5.68***	.063	.86
Math Content Knowledge	88.02	44.01	**5.74***	.064	.86
Mathematical Knowledge for Teaching	11.18	5.59	**6.74***	.074	.91

*$p \leq .007$, ** $p \leq .001$

RQ5: Prediction Models by Groups for Ethnicity, Teaching License, and Teaching Focus Using the Self-efficacy, Personal Beliefs Systems and Knowledge Model

Additional multiple regression analyses were run for each sub-group ethnicity (Hispanic, non-Hispanic), teaching focus (STEM, non-STEM), and teaching license (PST, non-PST). The separate regression analyses separated by group will determine if there are different prediction models based on group membership. Doing this provides a better understanding of the relationships between the demographic variables and self-efficacy for teaching mathematics.

Three standard multiple regressions were run for each of the following dichotomous groups: ethnicity (Hispanic, non-Hispanic), teaching focus (STEM, non-STEM), and teaching license (PST, non-PST). Separate regression analyses based on group membership were run using the model from research question 2. Self-efficacy for teaching mathematics was the response variable and self-efficacy for teaching, self-efficacy for doing math, beliefs about teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching as the predictor variables.

RQ5a. Self-efficacy, Personal Beliefs Systems and Knowledge Grouped by Ethnicity

A standard multiple regression analysis was run to answer the question: Are their different prediction models based on ethnicity in self-efficacy for teaching mathematics? Using the categories Hispanic and non-Hispanic, the response variable was self-efficacy for teaching mathematics (SETM). The predictor variables were self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK) and mathematical knowledge for teaching (MKT).

Hispanic. Results showed *R* for regression was significantly different from zero, $F_{(6, 74)} = 17.25$, $p < .001$, with R^2 at .58. The adjusted R^2 value of .55 indicates that over half of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs about teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 8): math content knowledge, self-efficacy for teaching, and self-efficacy for doing math.

The model explains 58% (55% adjusted) of the variance in self-efficacy for teaching mathematics, with 3 of the 6 variables making statistically significant contributions. Of the three statistically significant variables, math content knowledge was the strongest predictor, $\beta = .51$, $p < .001$, $r = .51$, followed by self-efficacy for teaching, $\beta = .40$, $p < .001$, $r = .49$, and self-efficacy for doing math, $\beta = .26$, $p = .007$, $r = .31$.

Non-Hispanic. Results showed *R* for regression was significantly different from zero, $F_{(6, 89)} = 25.11$, $p < .001$, with R^2 at .63. The adjusted R^2 value of .60 indicates that over half of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. Self-efficacy for doing math, beliefs about teaching math, math content knowledge, and self-efficacy for teaching had statistically significant regression coefficients (Table 8).

The model explains 63% (60% adjusted) of the variance in self-efficacy for teaching mathematics, with 4 of the 6 variables making statistically significant contributions. Of the four statistically significant variables, self-efficacy for doing math was the strongest predictor, $\beta = .44$, $p < .001$, $r = .49$, followed by beliefs about teaching math, $\beta = .31$, $p <$

.001, *r* = .38, math content knowledge, *β* = .28*, p* = .002, *r* = .32, and self-efficacy for teaching, *β* = .25, *p* = .003, *r* = .31.

Table 8. Multiple Regressions of Self-Efficacy, Beliefs, and Knowledge Variables Grouped by Ethnicity on Self-efficacy for Teaching Mathematics

Ethnicity		Mean	Standard Deviation	B	β	r
Hispanic						
N = 79	Self-efficacy Teaching Math	83.20	9.28			
$F_{(6, 74)}$=**17.25*****	Self-efficacy for Teaching	85.86	9.40	0.40	**0.40*****	0.49
	Self-efficacy Doing Math	82.66	10.70	0.22	**0.26****	0.31
R^2 = .58	Teach Math Beliefs	68.88	10.63	0.06	0.07	0.09
ADJ R^2 = .55	Math Beliefs	65.32	11.43	0.03	0.04	0.05
R = .76	Math content Knowledge	61.17	14.86	1.59	**0.51*****	0.51
	Mathematical Knowledge for Teaching	-0.90	0.92	-0.96	-0.10	-0.11
Non-Hispanic						
N = 93	Self-efficacy Teaching Math	82.49	12.65			
	Self-efficacy for Teaching	84.93	9.48	0.33	**0.25****	0.31
$F_{(6, 89)}$=**25.11*****	Self-efficacy Doing Math	79.53	13.64	0.41	**0.44*****	0.49
	Teach Math Beliefs	65.15	11.65	0.33	**0.31*****	0.38
R^2 = .63	Math Beliefs	61.89	9.43	-0.01	-0.01	-0.01
ADJ R^2 = .60	Math content Knowledge	68.91	14.02	1.27	**0.28****	0.32
R = .79	Mathematical Knowledge for Teaching	-0.58	0.98	0.25	0.02	0.02

*p ≤ .05, **p ≤ .01, ***p ≤ .001

RQ5b. Self-efficacy, Personal Beliefs Systems and Knowledge Grouped by Teaching Focus

A standard multiple regression analysis was run to answer the question: Are their different prediction models based on teaching focus in self-efficacy for teaching mathematics? Using the categories STEM and non-STEM, the response variable was self-efficacy for teaching mathematics (SETM). The predictor variables were self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK) and mathematical knowledge for teaching (MKT).

STEM. Results showed *R* for regression was significantly different from zero, $F_{(6, 88)} = 18.83$, $p < .001$, with R^2 at .56. The adjusted R^2 value of .53 indicates that over half of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 9): self-efficacy for doing math, self-efficacy for teaching and math content knowledge.

The model explains 56% (53% adjusted) of the variance in self-efficacy for teaching mathematics, with 3 of the 6 variables making statistically significant contributions. Of the three statistically significant variables, self-efficacy for doing math was the strongest predictor, $\beta = .37$, $p < .001$, $r = .39$, followed by self-efficacy for teaching, $\beta = .32$, $p < .001$, $r = .36$, and math content knowledge, $\beta = .32$, $p = .001$, $r = .33$.

Non-STEM. Results showed *R* for regression was significantly different from zero, $F_{(6, 75)} = 22.04$, $p < .001$, with R^2 at .64. The adjusted R^2 value of .61 indicates that over three-fifths of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 9): self-efficacy for doing math, beliefs about teaching math, math content knowledge, and self-efficacy for teaching.

The model explains 64% (61% adjusted) of the variance in self-efficacy for teaching mathematics, with 4 of the 6 variables making statistically significant contributions. Of the four statistically significant variables, math content knowledge was the strongest predictor, $\beta = .42$, $p < .001$, $r = .46$, followed by self-efficacy for teaching, $\beta = .36$, $p < .001$, $r = .46$, self-efficacy for doing math, $\beta = .35$, $p < .001$, $r = .43$, and beliefs about teaching math, $\beta = .27$, $p = .003$, $r = .33$.

Table 9. Multiple Regression Using Split File by Teaching Focus of Self-efficacy, Beliefs, and Knowledge on Self-efficacy for Teaching Mathematics

Teaching Focus		Mean	Standard Deviation	B	β	r
STEM						
N = 92	Self-efficacy Teaching Math	84.39	11.37	-0.25		
	Self-efficacy for Teaching	83.97	10.15	0.36	**0.32*****	0.36
$F_{(6, 88)}$=18.83***	Self-efficacy Doing Math	82.55	13.23	0.31	**0.37*****	0.39
R^2 =.56	Teach Math Beliefs	66.54	10.54	0.16	0.15	0.19
ADJ R^2 =.53	Math Beliefs	63.74	10.65	0.03	0.02	0.03
R =.75	Math Content Knowledge	67.84	14.62	1.23	**0.32*****	0.33
	Mathematical Knowledge for Teaching	-0.55	0.96	0.04	0.004	0.004
non-STEM						
N = 80	Self-efficacy Teaching Math	80.99	10.80	-20.95		
	Self-efficacy for Teaching	86.97	8.29	0.46	**0.36*****	0.46
$F_{(6, 75)}$=**22.04*****	Self-efficacy Doing Math	79.12	11.27	0.33	**0.35*****	0.43
	Teach Math Beliefs	67.24	12.21	0.24	**0.27****	0.33
R^2 =.64	Math Beliefs	63.14	10.39	-0.02	-0.02	-0.03
ADJ R^2 =.61	Math content Knowledge	62.50	14.75	1.55	**0.42*****	0.46
R =.80	Mathematical Knowledge for Teaching	-0.93	0.93	-1.13	-0.10	-0.11

*$p \le .025$, **$p \le .01$, ***$p \le .001$

RQ5c. Self-efficacy, Personal Beliefs Systems and Knowledge Grouped by Teaching License

A standard multiple regression analysis was run to answer the question: Are their different prediction models based on teaching license in self-efficacy for teaching mathematics? Using the categories PST and non-PST, the response variable was self-efficacy for teaching mathematics (SETM). The predictor variables were self-efficacy for teaching (SET), self-efficacy for doing mathematics (SEDM), beliefs about teaching mathematics (TM Beliefs), beliefs about mathematics (M Beliefs), mathematical content knowledge (MCK) and mathematical knowledge for teaching (MKT).

PST. Results showed *R* for regression was significantly different from zero, $F_{(6, 130)}$ = 26.26, $p < .001$, with R^2 at .57. The adjusted R^2 value of .55 indicates that over half of the variability in self-efficacy for teaching mathematics is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 10): self-efficacy for doing math, beliefs about teaching math, math content knowledge, and self-efficacy for teaching.

The model explains 57% (55% adjusted) of the variance in self-efficacy for teaching mathematics, with 4 of the 6 variables making statistically significant contributions. Of the four statistically significant variables, self-efficacy for doing math was the strongest predictor, $\beta = .40$, $p < .001$, $r = .45$, self-efficacy for teaching, $\beta = .29$, $p < .001$, $r = .36$, math content knowledge, $\beta = .28$, $p = .001$, $r = .29$, and followed by beliefs about teaching math, $\beta = .14$, $p = .046$, $r = .17$.

Non-PST. Results showed *R* for regression was significantly different from zero, $F_{(6, 33)} = 13.70$, $p < .001$, with R^2 at .72. The adjusted R^2 value of .66 indicates that two-thirds of the variability in self-efficacy for teaching mathematics for non-PSTs is predicted by: self-efficacy for teaching, self-efficacy for doing math, beliefs bout teaching math, beliefs about math, math content knowledge, and mathematical knowledge for teaching. The following factors had statistically significant regression coefficients (Table 10): math content knowledge, self-efficacy for teaching, and beliefs about teaching math.

The model explains 72% (66% adjusted) of the variance in self-efficacy for teaching mathematics, with 3 of the 6 variables making statistically significant contributions. Of the three statistically significant variables, math content knowledge was the strongest predictor, $\beta = .42$, $p = .001$, $r = .55$, followed by, and beliefs about teaching math, $\beta = .34$, $p = .01$, $r = .43$, and self-efficacy for teaching, $\beta = .29$, $p = .021$, $r = .39$. PSTs are learning pedagogical content knowledge separate from their non-PST peers. The group effects show there is a difference in how PSTs and non-PSTs believe they would teach mathematics.

Table 10. Multiple Regression Grouped by Teaching License for Self-efficacy, Beliefs, and Knowledge Variables on Self-efficacy for Teaching Mathematics

Teaching License		Mean	Standard Deviation	B	β	r
PST						
N = 137	Self-efficacy Teaching Math	83.81	10.26	1.42		
$F_{(6, 130)}$=26.26***	Self-efficacy for Teaching	85.54	9.31	0.32	**0.29*****	0.36
R^2 = .57	Self-efficacy Doing Math	81.51	12.36	0.33	**0.40*****	0.45
ADJ R^2 = .55	Teach Math Beliefs	65.68	10.46	0.14	0.14	0.17
R = .75	Math Beliefs	62.30	9.96	0.10	0.10	0.13
	Math content Knowledge	67.23	15.22	0.95	**0.28*****	0.29
	Mathematical Knowledge for Teaching	-0.60	0.96	0.58	0.05	0.06
Non-PST						
N = 40	Self-efficacy Teaching Math	79.40	13.57	-23.41		
$F_{(6, 33)}$=13.70***	Self-efficacy for Teaching	84.73	9.92	0.40	**0.29***	0.39
R^2 =.72	Self-efficacy Doing Math	79.07	12.71	0.25	0.23	0.32
ADJ R^2 =.66	Teach Math Beliefs	70.91	13.21	0.35	**0.34****	0.43
R =.85	Math Beliefs	67.46	11.45	-0.12	-0.10	-0.17
	Math content Knowledge	59.00	11.72	2.44	**0.42*****	0.55
	Mathematical Knowledge for Teaching	-1.16	0.88	-3.03	-0.20	-0.29

*p ≤ .025, **p ≤ .01, ***p ≤ .001

Results Summary

Results suggest that both domain specific self-efficacy (teaching) and content-specific self-efficacy (math) are related to and predictive of a domain and content specific self-efficacy (teaching math). The content specific self-efficacy for doing math was consistently the single largest predictor of self-efficacy for teaching mathematics, followed by math content knowledge, and the domain specific self-efficacy for teaching (Table 11). Beliefs about teaching math was also consistently a statistically significant predicting variable in the majority of the regression equations. There is a chance it would have been statistically significant in all of the equations, had the sample size been larger in the sub-group categories, as its *p*-value was always just over the criteria for the set alpha level. The one surprise was with the MKT and its lack of statistically significant regression coefficients in any of the regression analyses.

Table 11. Summary of Regression Equations by Research Question

Research Question	F	R^2	ADJ R^2	Regression Equation
1. Self-Efficacy	$F_{(2, 157)} = 82.24$	0.48	0.48	SETM’ = .53SEDM’ + .28SET’
2. SE, Beliefs & Knowledge	$F_{(6, 170)} = 40.61$	0.59	0.58	SETM’ = .38SEDM’ + .30SET’+ .37MCK’ + .23TMB’
3. SE, Beliefs, Knowledge & Demographic	$F_{(11, 160)} = 24.22$	0.63	0.60	SETM’ = .37SEDM’ + .32SET` + .34MCK’+ .23TMB’ + .12TF’ + -.12TL’
5a. Hispanic	$F_{(6, 74)} = 17.25$	0.58	0.55	SETM’ = .26SEDM’ + .40SET’ + .51MCK’
Non-Hispanic	$F_{(6,89)} = 25.11$	0.63	0.60	SETM’ = .44SEDM’ + .25SET’ + .28MCK’ + .25TMB’
5b. STEM	$F_{(6,88)} = 18.83$	0.56	0.53	SETM’ = .37SEDM’ + .32SET’ + .32MCK’
Non-STEM	$F_{(6,75)} = 22.04$	0.64	0.61	SETM’ = .35SEDM’ + .36SET’ + .42MCK’ + .27TMB’
5c. PST	$F_{(6, 130)} = 26.26$	0.57	0.55	SETM’ = .40SEDM’ + 29SET’ + .28MCK’ + .27TMB’
Non-PST	$F_{(6,33)} = 13.70$	0.72	0.66	SETM’ = .29SET’ + .42MCK’ + .34TMB’

There were minor exceptions to this pattern based on the sub-groups: Hispanics, non-STEM, and non-PSTs. In these instances, self-efficacy for teaching was the stronger predictor of the two self-efficacy variables, but math content knowledge was the single largest predictor. For these three groups, the pattern was three statistically significant predictor variables (from strongest to less strong): math content knowledge, self-efficacy for teaching, and either beliefs about teaching math (teaching focus & teaching license) or self-efficacy for doing math (ethnicity). These three groups had the lowest mean scores on both of the knowledge assessments, had higher mean scores on the beliefs instruments (suggesting less adaptive beliefs), and lower mean scores on the self-efficacy instruments (with one exception: non-STEM had a higher mean SET score than the STEM group). The lower scoring groups' perceived capability to teach mathematics was determined predominately by math content knowledge and self-efficacy for teaching. When self-efficacy beliefs for doing math and math content knowledge were low, self-efficacy for teaching was high, suggesting the participants may hold naïve beliefs that low self-efficacy in one domain (doing math) can be compensated for by high self-efficacy in a separate but related domain (teaching). A PST with a low self-efficacy for doing math may still hold high self-efficacy beliefs for teaching math if they have high self-efficacy for teaching.

When demographic variables were included, teaching focus and teaching license were also statistically significant predictors of self-efficacy for teaching math. Both teaching focus (STEM non-STEM) and teaching license (PST, non-PST) had statistically significant group differences as well as statistically significant regression coefficients from the multiple regression analysis. This means there are meaningful differences in self-efficacy for teaching mathematics by group membership on the variables teaching focus and license, and that these same variables are also predictors of self-efficacy for teaching mathematics.

CHAPTER 5

DISCUSSION

The following chapter contains a discussion of the study's findings in relation to its goals, as well as the implications, limitations, and directions for future research. The goal of the present study was to better understand the complex relationships involved in the formation of an individual's self-efficacy. More specifically, this study examined a variety of relationships to better understand what constitutes pre-service teachers' self-efficacy for teaching mathematics. To accomplish this goal, a series of analyses explored the possible relationships between self-efficacy for teaching, and self-efficacy for doing math, beliefs about math and teaching math, and math content knowledge and mathematical knowledge for teaching.

Additional analyses examined how and in what ways group membership may have had effects on self-efficacy for teaching mathematics. Results suggest that domain and content specific self-efficacy, in this case self-efficacy for teaching mathematics, is related to and predicted by the lesser domain specific self-efficacy for doing mathematics and self-efficacy for teaching mathematics. The addition of math content knowledge and beliefs about teaching math made a statistically significant change to the overall model and were statistically significant contributors to the prediction models. The addition of the demographic variables made a statistically significant improvement to the model's overall fit, but only teaching focus and teaching license were statistically significant predictors of self-efficacy for teaching math. When the regressions were run with separate groups to differentiate differences in the prediction model based on individual characteristics, both teaching license and ethnicity had slightly different equations, whereas teaching focus

Research Question	Results
1) Do self-efficacy for teaching and self-efficacy for doing mathematics predict self-efficacy for teaching mathematics? Is one more predictive than the other? Does each type of self-efficacy belief offer a unique contribution, or can the more general measures of self-efficacy be used in lieu of the more domain and content specific self-efficacy for teaching mathematics?	Yes: Self-efficacy for Teaching Mathematics is predicted by self-efficacy for doing math, and self-efficacy for teaching. Each type of self-efficacy beliefs is a distinct construct. Self-efficacy for doing math (r=.55) was a stronger predictor than self-efficacy for teaching (r = .33). Combined the two domain specific self-efficacy beliefs accounted for 48% of the variance.
2) Do self-efficacy beliefs about doing math and teaching, personal belief systems and performance knowledge about math and teaching math predict self-efficacy for teaching mathematics?	Yes: Self-efficacy for Teaching Mathematics is predicted by self-efficacy for doing math, self-efficacy for teaching, math content knowledge and beliefs about teaching math.
3) Do personal characteristics, self-efficacy beliefs for teaching and doing math, personal belief systems about math and teaching math, math content and mathematical knowledge for teaching predict self-efficacy for teaching mathematics?	Yes: Self-efficacy for Teaching Mathematics is predicted by teaching focus, teaching license, self-efficacy for doing math, self-efficacy for teaching, math content knowledge and beliefs about teaching math.
4) Are there group differences in pre-service teachers' self-efficacy beliefs for teaching, doing math, and teaching math, personal belief systems about math and teaching math, math content and mathematical knowledge for teaching based on PSTs personal characteristics and choices?	Yes: There were multivariate group differences based on ethnicity, teaching focus, and teaching license. For ethnicity it was in mathematics content knowledge; teaching focus: self-efficacy for teaching mathematics, math content knowledge, and mathematical knowledge for teaching; teaching license: beliefs about math, math content knowledge, and mathematical knowledge for teaching.
5) Does group membership change the prediction model for pre-service teachers' self-efficacy for teaching mathematics based on their self-efficacy beliefs about teaching and doing math, personal belief systems and performance knowledge of math and teaching math?	Yes: There are differences in how self-efficacy for teaching mathematics is predicted by different groups. The core predicting variables were: self-efficacy for doing mathematics, self-efficacy for teaching, math content knowledge, and beliefs about teaching math. These were the only variables with statistically significant regression coefficients out of the six independent variables in all of the regression analyses.

yielded the same variables in the equation but with slightly different pattern in strength of prediction.

The results suggest that pre-service teachers differ from the participants who are not planning to be classroom teachers in their self-efficacy for teaching mathematics. The PST group had a broader, more adaptive set of beliefs about teaching math, better math content knowledge, and higher levels of all three types of self-efficacy. Perhaps the difference is due to college coursework completed, with the PST students' education coursework having made an impact on their beliefs about teaching, math content knowledge, and types of self-efficacy. A large component of the educational psychology courses in which the participants were enrolled teach meta-cognition and self-awareness. Perhaps as a result, the PSTS have a better understanding/awareness of all the learning process and that effective teaching and learning involve more than mastering content knowledge.

It could also be that the average PST had a different educational experience as students themselves, which may be a reason they are now choosing to become teachers. There were no statistically significant difference between Early Childhood/Elementary level teacher and Secondary teachers, but there were differences between both these groups and the other/non-educator group, the non-PSTs. Additional exploration into the differences between PSTs and non-PSTs would yield beneficial information about these differences. Some of the non-PST participants know they will be in the field of education, while others either did not know or thought they would not be, yet they were enrolled in an education course, so there may be an underlying interest in education/becoming a teacher that they have not yet fully realized. The non-PST results are limited in that there was a small sample size

($N = 40$), and contained both educators and non-educators. There may be additional differences in these two groups that would be revealed with a larger sample size.

Given the consistently low scores on the MKT assessment by all participants, it is likely that the instrument was assessing types of knowledge the participants had not yet mastered, and was far outside of their frames of reference. The scores on the DTAMS assessment indicate the participants are still expanding their type I and II levels of math knowledge, and the MKT confirms the rudimentary nature of their type III and IV specialized and pedagogical content knowledge, aka mathematical knowledge for teaching.

It is possible that performing poorly and/or struggling with the MKT assessment gave the participants, especially the PSTs, some perspective as to the type of situations and questions they may encounter while teaching math. The MKT may have taught the participants that they do not know as much about teaching math as they thought they did. Learning this while still in their education programs may provide them the opportunity to seek out and learn what they need to know, to be as effective as they imagined themselves to be whilst completing the self-efficacy for teaching mathematics instrument (SETMI). In this regard, the MKT's formative assessment design would be beneficial for PSTs to take at the beginning and the end of their teacher education programs, as the pre-assessment would provide insight into the things the PSTs did not know they did not know, and the post-assessment would help them see what they have learned and what they still need to work on as new teachers.

Even though the MKT assessment was not a statistically significant predictor of SETM, it was still provided valuable contributions to the overall goal of better understanding the complex relationships present in the formation of SETM. The MKT exemplifies the complexity, as it statistically significant correlations with the majority of the other IVs, and in the ANOVAs found groups differences based on teaching focus and teaching license. Again, it should be noted that due to the limited nature of their classroom teaching experiences, the MKT is measuring types of knowledge the PSTs have not yet developed (Linsell & Anakin, 2012; R. A. Philipp & Sowder, 2002; R. A. Philipp et al., 2007).

What this study found was that the vast majority of the participants think themselves capable of teaching math (*M* = 82.70) without having the basic math knowledge necessary to effectively teach math (*M* = 65.52%). Compensating for their lack of knowledge in their perceived ability to teach math is the overall perception that they are going to be an effective teacher in general, regardless of content area. This may be especially relevant for early childhood and elementary level teachers, who are generally responsible for teaching all core subjects, but may not have equal levels and types of knowledge in all of the core content areas. This implies that in instances where there is low content knowledge, self-efficacy for teaching becomes more important.

Directions for Future Research

There is an emerging pattern in terms of the changes in self-efficacy, beliefs, and knowledge between pre-service teachers, novice teachers, and experienced teachers. It appears the PSTs are entering their teaching careers with a skewed vision of what it's going to be like and how they are going to teach. The first three years as an educator is often a harsh reality check that many new teachers will not recover from. The attrition rate for new teachers leaving the profession after their first three years of teaching is around 50%. "Individuals confused the requirements and preparation needed to become a teacher with the actual knowledge that is needed to facilitate classroom instruction. Perhaps this reflects a larger problem –that pre-service and practicing teachers do not recognize or value the specific knowledge that is unique and needed within the teaching profession" (Fives & Buehl, 2008, p. 398). Prior research has discovered some of the causes: an inflated sense of self-efficacy for teaching and proficiency only in the lower levels of knowledge acquisition (Linsell & Anakin, 2012; R. A. Philipp et al., 2007; Seaman & Szydlik, 2007; Tschannen-Moran & Woolfolk Hoy, 2007; Woolfolk Hoy & Spero, 2005). While the PSTs had more adaptive beliefs about math and teaching math than the non-PST group, more information is needed to discern whether these differences existed upon entering college or whether or not the differences are due to a change in beliefs from chosen coursework. Do PSTs enter college knowing they want to be teachers, already in possession of a different and more adaptive set of beliefs than non-PST undergraduates or undergraduates deciding to go into teaching after being in college? Are the PSTs learning material in their education courses that is actively addressing and changing their beliefs about teaching math?

The small sample size and manner in which participants were asked to list all their college coursework related to the teaching of mathematics prohibits this study from the examination of these questions. Instead of leaving it up to the participants to enter the names of the courses and course numbers, a list of all possible courses of interest should be generated for the participants to select from. An "other" text box would be necessary for students to include courses taken at other institutions, and they should be asked to refer to their course syllabus and/or academic transcript for the course name and number. They should also be asked to indicate whether each course was a teaching methods course, a math content course, or a combination of the two. They should also indicate whether the course was a remedial course. The courses students select to complete their requirements may determine the level to which they experience meaningful learning and/or change. Taking a math for teachers course offered in the mathematics department may not offer the same benefits as a teaching mathematics course offered in the teacher education department. Cross-listed courses may depend on the home department of the course professor, so it would be beneficial to ask them to list the professor/instructor's name and department.

In terms of training, experience, and depth of knowledge, it would also be prudent to ask whether the course was taught by a professor, adjunct faculty, or graduate student. Even if they don not know the answer, the mere asking of the question my get them to realize they may want to start care who is teaching them (Masingila et al., 2012). Lastly, since it is a new and extremely popular trend, the participants should indicate whether it was an online or traditional course. The low overhead and high enrollment capabilities of online courses make them appealing to University's finial bottom lines (they are cash cows), so insight into the differences of the learning experiences of students in online versus in-person courses is essential and urgent. How does the removal of interpersonal learning experiences affect students' overall learning experiences?

Additional information about the participants' perceptions of their completed coursework, remaining coursework, and amount of classroom exposure they have and will receive should be ascertained. Do they believe their programs will provide them the education and training necessary to achieve their goals as teachers? Some qualitative questions about their educational experiences and the ways in which they believe their programs could better assist them in their learning would provide insight into that PSTs believe is important and value as well as how the program could actually be improved.

How do the educational experiences of PSTs differ from non-PSTs, especially in regards to their decision to choose teaching as their career aspiration? Were they exposed to a wider variety or more positive array of social models? Did they receive more verbal persuasions to encourage their pursuit of teaching? Perhaps it was one teacher and or a particular transformative experience (Usher et al., 2008). More information is needed to determine how PSTs and non-PSTs differ in their self-efficacies, beliefs, and knowledge, and whether or not these differences exist prior to their entering college or if they are developed throughout their college education through their choice of majors. Additionally, a longitudinal examination of how PSTs self-efficacies, beliefs, and knowledge change from the beginning of their teaching programs to the end of their coursework, pre- and post-student teaching, and throughout their first three years of teaching, would yield an incredible amount of insight into the metamorphosis of a teacher.

Teacher education programs, particularly the ones at the institution involved in this study, have adopted major research based changes into how they approach teaching PSTs. One of the new changes involves increasing the amount of exposure and time PSTs spend inside actual K-12 classrooms. Research shows the earlier students entered real classrooms and the more time they spend there greatly enhances the educational impact of their programs. It used to be that PSTs would complete all of their coursework prior to entering an actual classroom, with the exception of a two-week observational period prior to the semester or year of student teaching, which would not typically occur until their senior year, oftentimes the second semester of their senior year. Consistent with social cognitive theory, placing PSTs in the classroom from the beginning of their programs provides them a context and concrete environment from which they receive education and training in all four sources of self-efficacy, instead of an over-emphasis on mastery experiences from coursework alone.

Another change in teacher education program has been a move towards discourse, increased emphasis on peer learning, learning from authentic experiences, the explicit examination of personal belief systems, including self-beliefs like self-efficacy, self-regulation, and self-determination. PSTs are learning by doing, examining, discussing, and self-reflecting.

The study by Woolfolk Hoy and Spero (2005) showed why efforts should be made to match student teaching experiences to the most probable future teaching assignments of the novice teachers. Even better would be for PSTs to be exposed to a wide variety of schools and educational settings: public, charter, private, religious; schools with high, mid- and low SES student populations; elementary, middle, and high school classrooms; school with a range of student populations, from homogenous exceptionally diverse; full-inclusion classrooms or regular classrooms with special education students separated; schools with small populations to the largest schools; Bilingual schools and classroom and schools with students who are English language learners (ELLs); schools known to have strong parental and community support and schools that are considered to filing and have high “at risk” populations. The list could go on and on, and it writing it the difficulties of executing this idea became apparent. However, it would be possible for colleges and universities with teacher education programs could partner with schools and teachers to create a series of online or virtual classroom experiences and video tours of each school for PSTs to explore. Additionally, ways to increase PSTs opportunities to receive social and verbal persuasions from their peers about their teaching should be explored.

APPENDIX A: DEMOGRAPHIC QUESTIONNAIRE

1) What is your age?

2) What is your gender?
    - Female
    - Male

3) What is your race, ethnicity, or ancestry? Check all that apply.
    - American Indian, Native American, Alaska Native
    - Asian/Asian American
    - Black/ African American
    - Hispanic/ Latino/a
    - Native Hawaiian/ Pacific Islander
    - White/Caucasian
    - Other(s) ___________________________________

4) What is your year in school?
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Post-Baccalaureate
    - Graduate Student

5) Within the university, in which **college or school** are you currently enrolled?
    - Business School
    - College of Arts & Sciences
    - College of Education
    - College of Fine Arts
    - College of University Libraries & Learning Sciences
    - School of Architecture and Planning
    - School of Engineering
    - University College
    - Non-Degree
    - Other ____

6) If enrolled in the College of Education, what is your **major**?
    - Art Education
    - Athletic Training
    - Counselor Education
    - Early Childhood Multicultural education
    - Educational Leadership and Organizational Learning
    - Educational Linguistics
    - Educational Psychology
    - Elementary Education

- Exercise Science
- Family Studies
- Health Education
- Language, Literacy, and Sociocultural Studies
- Nutrition
- Physical Education Teacher Education
- Secondary Education
- Special Education
- Sports Administration
- Teacher Education
- Non-Degree
- N/A
- Other:______________________________________

7) If enrolled in the College of Arts & Sciences, what is your **major**?
    - American Studies
    - Anthropology
    - Biology
    - Chemistry & Chemical Biology
    - Communication & Journalism
    - Earth & Planetary Sciences
    - Economics
    - English
    - Foreign Language & Literature
    - Geography
    - History
    - Linguistics
    - Mathematics & Statistics
    - Philosophy
    - Physics & Astronomy
    - Political Science
    - Psychology
    - Sociology
    - Spanish & Portuguese
    - Speech & Hearing Sciences
    - University College
    - Non-Degree
    - N/A
    - Other ________________________

8) If enrolled in a College other than Education or Arts, & Sciences, please write the name of your **major and/or department** in which you are majoring.

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____

9) What is the target teacher license you are working to obtain? Include either traditional or alternative licenses.
   - Blind and Visually Impaired (Birth-12th grade)
   - Early Childhood (Birth-3rd Grade)
   - Elementary (Kindergarten-8th Grade)
   - Middle Level (5th-9th Grade)
   - Specialty (Pre-Kindergarten-12th Grade)
   - Secondary (7th-12th Grade)
   - Secondary Vocational Technical (7th-12th Grade)
   - Special Education (Pre-Kindergarten-12th Grade)
   - OR Any Type of Instructional Support Provider Licensure
   - OR Education Administration (Pre-Kindergarten-12th Grade)
   - None
   - Other ____

10) What is your Teaching Focus (the content area in which you will have completed at least 24 credit hours)?
   - Mathematics
   - Science
   - History
   - Language Arts
   - Foreign Languages
   - Reading
   - Elementary Education
   - Special Education
   - Bilingual Education/TESL
   - Other ____

11) Please check and/or list the mathematics courses you completed in HIGH SCHOOL.
   - Algebra 1
   - Algebra 2
   - Geometry
   - Probability & Statistics
   - Pre-Calculus
   - Calculus
   - Financial Literacy
   - Other(s) ____

12) Please list all of the COLLEGE LEVEL mathematics courses you have completed.

Dept/Course #	Course Name	# of Credit Hours

13) Please list all the COLLEGE LEVEL mathematics courses you plan on taking to complete your degree and/or licensure program (include only courses not listed above).

Dept/Course #	Course Name	# of Credit Hours

APPENDIX B: SELF-EFFICACY FOR TEACHING MATHEMATICS INSTRUMENT (SETMI) ITEMS, MEANS & STANDARD DEVIATIONS

SETMI α = .92 Item Text	Mean	Standard Deviation
1. I can motivate students who show low interest in mathematics.	72.50	20.44
2. I can help my students' value learning mathematics.	77.41	18.66
3. I can craft relevant questions for my students related to mathematics.	78.77	19.91
4. I can get my students to believe they can do well in mathematics.	82.26	16.67
5. I can use a variety of assessment strategies in mathematics.	77.49	20.53
6. I can provide an alternative explanation or example in mathematics when students are confused.	78.88	18.21
7. I can implement alternative teaching strategies for mathematics in my classroom.	78.12	19.39
8. I can describe the characteristics of different types of numbers (i.e. whole numbers, rational numbers, irrational numbers, etc.).	80.14	18.62
9. I can perform strategies for composing and decomposing numbers by manipulating place value in addition and subtraction.	84.46	17.60
10. I can perform strategies for composing and decomposing numbers by manipulating place value in multiplication and division.	83.67	17.30
11. I can convert a fraction to a decimal and vice versa.	89.88	17.45
12. I can compare equivalence of fractions and decimals.	86.89	18.29
13. I can interpret inverse relationships between operations (i.e. +, - and *, ÷).	90.88	13.43
14. I can manipulate coordinate planes.	77.36	23.25
15. I can collect, plot and interpret data (on any type of graph).	87.97	16.54
16. I can measure the area and perimeter of a given shape or space.	90.75	14.61
17. I can convert between units in the same system (i.e. grams -> kilograms, inches -> yards).	78.40	21.26
18. I can convert between units in a different system (i.e. kilograms -> pounds, inches -> centimeters).	74.70	23.36
19. I can measure the length of objects.	95.86	9.18
20. I can discover and create mathematical patterns.	84.22	16.40
21. I can interpret the variables in an algebraic equation.	87.34	15.16
22. I can interpret the probability of outcomes.	80.88	18.48

APPENDIX C: TEACHERS' SENSE OF EFFICACY SCALE (TSES) ITEMS, MEANS & STANDARD DEVIATIONS

TSES α = .96 Item Text	N	Mean	Standard Deviation
1. I can get through to the most difficult students.	184	72.17	17.94
2. I can help my students think critically.	184	80.03	15.20
3. I can control disruptive behavior in the classroom.	184	81.09	15.35
4. I can motivate students who show low interest in schoolwork.	184	81.09	15.33
5. I can make my expectations clear about student behavior.	184	90.93	10.26
6. I can get students to believe they can do well in schoolwork.	184	87.66	12.50
7. I can respond to difficult questions from my students.	184	83.97	13.33
8. I can establish routines to keep activities running smoothly.	184	88.82	11.38
9. I can help my students value learning.	184	87.69	12.34
10. I can gauge student comprehension of what I have taught.	184	85.22	12.84
11. I can craft good questions for my students.	184	85.49	13.39
12. I can foster student creativity.	184	87.14	12.75
13. I can get students to follow classroom rules.	181	86.58	11.41
14. I can improve the understanding of a student who is failing.	181	82.60	14.24
15. I can calm a student who is disruptive or noisy.	181	83.57	13.87
16. I can establish a classroom management system with each group of students.	181	86.17	13.06
17. I can adjust my lessons to the proper level for individual students.	181	86.22	13.82
18. I can use a variety of assessment strategies.	181	86.56	13.64
19. I can keep a few problem students from ruining an entire lesson.	181	84.93	13.51
20. I can provide an alternative explanation or example when students are confused.	181	87.72	11.23
21. I can respond to defiant students.	181	85.73	13.73
22. I can assist families in helping their children do well in school.	181	85.85	12.54
23. I can implement alternative strategies in my classroom.	181	87.48	11.84
24. I can provide appropriate challenges for very capable students.	181	89.65	9.85

APPENDIX D: SELF-EFFICACY FOR DOING MATHEMATICS (SEDM) ITEMS, MEANS AND STANDARD DEVIATIONS

SEDM α = .95

Item text	Mean	SD
1. I can complete advanced mathematics problems with clarity and ease.	67.28	24.26
2. I can take a mathematics competence test without having time to prepare.	64.45	27.17
3. I can solve non-routine mathematical problems (for example, problems that require novel or non-formulaic thinking).	67.51	24.95
4. I can apply mathematical concepts to "real-world" problems.	80.05	17.09
5. I can make estimates, predictions or hypotheses	83.45	15.77
6. I can analyze data to make inferences or draw conclusions.	82.96	15.83
7. I can work on a problem that takes at least 45 minutes to solve.	67.96	28.81
8. I can work with manipulatives (for example, counting blocks, geometric shapes, or algebraic tiles) to understand concepts.	84.89	18.75
9. I can measure objects using tools such as rulers, scales, or protractors.	91.80	11.28
10. I can collect data by counting, observing, or conducting surveys.	89.99	13.78
11. I can solve word problems.	85.54	15.12
12. I can explain my reasoning or thinking in solving a problem, using several sentences.	85.36	14.81
13. I can work on a math assignment, report, or project that takes longer than one week to complete.	78.61	23.28
14. I can learn mathematical concepts and procedures by watching someone else demonstrate how to do a procedure or solve a problem.	84.60	15.37
15. I can read about mathematics in books, magazines, or articles (not textbooks) and understand the material.	69.01	25.04
16. I can complete computational exercises or procedures from a textbook or a worksheet.	80.59	18.80
17. I can present or demonstrate my solutions to a math problem to the whole class.	83.76	17.27
18. I can work individually on mathematics exercises, problems, investigations, or tasks.	86.29	17.19
19. I can work in pairs or small groups on math exercises, problems, investigations, or tasks.	85.83	16.74
20. I can use computers, calculators, or other technology (video games, apps, etc.) to learn mathematics.	88.98	12.36
21. I can take a quiz or test in mathematics if I have time to study and prepare.	91.74	11.92
22. I can collect, analyze, and display data	88.66	12.12
23. I can solve an extended response problem for which you must explain or justify your solution.	82.29	16.49
24. I can quickly and accurately recall multiplication facts through 12x12 on command.	82.36	22.42
25. I can perform calculations regarding important matters, like finances, accurately without using a calculator or any other technological assistance.	71.76	24.57

APPENDIX E: T.E.A.C.H. MATH BELIEFS SURVEY ITEMS, MEANS & STANDARD DEVIATIONS

TM Beliefs α = .60 Item Text	Mean	Standard Deviation
1. Children should solve word problems before they master computational procedures.	54.59	31.77
2. Teachers should encourage children to find their own solutions to math problems even if they are inefficient.	67.26	29.83
3. An effective teacher demonstrates the right way to do a word problem.	75.22	25.95
4. Children should understand the meaning of an operation (addition, subtraction, multiplication, division) before they memorize number facts.	84.13	22.13
5. Even children who have not learned basic facts can have effective methods for solving problems.	81.21	23.90
6. Children should solve problems the way the teacher has taught them.	44.93	28.98
7. Children learn math best by figuring out for themselves how to solve math problems.	63.39	27.84
8. Children will not understand an operation (like multiplication) until they have mastered some of the relevant number facts (like the times tables).	55.59	34.34
9. Children should be allowed to invent ways to solve word problems before the teacher demonstrates how to solve them.	71.18	26.83
10. Most children cannot figure out math for themselves and must be explicitly taught.	49.04	29.65
11. Allowing children to discuss their thinking helps them to make sense of mathematics	91.11	12.64
12. Teachers should allow children who are having difficulty solving word problems to continue to try to find a solution.	77.20	24.43
13. Children can figure out ways to solve many math problems without formal instruction.	65.54	26.71
14. Children need explicit instruction on how to solve word problems.	58.88	45.82
15. Teachers should tell children who are having difficulty solving a word problem how to solve the problem.	60.89	29.03

APPENDIX F: BELIEFS ABOUT MATHEMATICS SURVEY ITEMS, MEANS, & STANDARD DEVIATIONS

Math Beliefs α = .70 N = 184	Mean	SD
1. Mathematics is a web of interrelated concepts and procedures.	87.56	15.52
2. Knowledge of how to apply mathematical procedures does not necessarily go with understanding of the underlying concepts.	64.38	29.13
3. Understanding mathematical concepts is more powerful and useful than remembering mathematical procedures.	79.52	20.98
4. Mathematics is a collection of rigid rules and mysterious procedures that seem to be unrelated to each other.	37.77	33.88
5. It’s socially acceptable and cool to be good at math.	74.70	27.74
6. Mathematics is a difficult and demanding subject to learn.	71.95	24.50
7. Mathematics is a subject in which it is socially acceptable to do poorly.	49.57	35.19
8. Mathematical thinking is important to people even if they do not actually "do" mathematics in their employment capacity.	84.93	17.20
9. The pervasive role of mathematics is underestimated in the world of everyday living.	77.72	24.78
10.A person’s mathematical intelligence is something that cannot be changed very much.	35.59	32.50
11. People can learn new things in mathematics, but they can’t really change their basic intelligence.	38.94	34.49
12. By trying hard, you can become smarter in math.	88.09	16.76
13. The difference between people who are outstanding in math and those who have a lot of difficulty in math is due to differences in their genetic make up.	35.19	31.41
14. Genetic differences account for differences between how boys and girls perform in math.	33.79	31.89
15. Mathematics consists of a set of straightforward facts, rules and formulas.	68.29	28.05
16. Taking time to investigate why a solution to a math problem works is time well spent.	82.45	20.64
17. A person who does not understand why an answer to a math problem is correct has not really solved the problem.	78.42	21.97
18. Effort and practice can improve a person’s ability in mathematics.	90.60	14.71
19. It is more important to understand why the answer is correct than it is to get the correct answer.	84.03	20.32
20. To be good at math, you have to have a “Math Mind”.	36.67	32.61
21. Getting the correct answer is the only thing that matters.	26.29	31.44
22. Math is beautiful.	68.23	33.40

APPENDIX G: DIAGNOSTIC TEACHER ASSESSMENTS FOR MATHEMATICS AND SCIENCE (DTAMS) ITEMS, MEANS, & STANDARD DEVIATIONS

DTAMS α = .66 Item Text	Mean	SD
1W. Which means the same as 2 ten thousands, 12 thousands, and 15 ones?	0.60	0.49
2R. What is 4 minus 2 1/6?	0.89	0.32
3A. Which of the following is the median for the data set: 4, 9, 3, 5, 10, 3?	0.62	0.49
4G. Lines l and m are parallel. Line n is not perpendicular to line l and it is not perpendicular to line m. Which angles are congruent in the drawing?	0.53	0.50
5A. The graph shows the average salary of workers 18 years and older based on education.	0.89	0.32
6A. Which of the following statement does NOT accurately describe the data shown?	0.68	0.47
7G. Folding Figure E along the line segments at the base of each triangle can create which three-dimensional shape?	0.15	0.35
8W. Which of the following is expanded notation for the number 830,002?	0.78	0.41
9A. A bag contains 1 yellow color tile, 4 red color tiles, and 3 blue color tiles. What is the probability of drawing a blue color tile?	0.92	0.27
10R. Which of the following is listed from least to greatest?	0.89	0.31
11G. If BF is perpendicular to EA which statement below is true about the diagram?	0.48	0.50
12W. Solve: : -12 – (-9 – 3) = [ ]	0.59	0.49
13A. What are the coordinates of point A?	0.93	0.25
14R. The models are shaded to show that	0.89	0.31
15G. Which of these is the formula for finding the area of a triangle?	0.87	0.34
16W. If a number N has exactly three divisors, then N can only be	0.14	0.34
17G. How many faces, edges and vertices does a hexagonal pyramid have?	0.35	0.48
18R. Which of the following numbers is the closest in value to 0.78?	0.53	0.50
19A. Sharon delivered 2 more cases of bottled water than DeMarcus and Torian delivered 3 times as many as Sharon. If DeMarcus delivered n cases of bottled water, which of these represents the number of cases that Torian delivered?	0.78	0.42
20R. Which number in the set shown below is NOT equivalent to the others?	0.60	0.49

APPENDIX H: MATHEMATICAL KNOWLEDGE FOR TEACHING (MKT) ELEMENTARY NUMBERS AND COMPUTATION ASSESSMENT ITEMS, MEANS, & STANDARD DEVIATIONS

MKT α = .78 Item Text	Mean	SD
MKT1	0.45	0.50
MKT2	0.42	0.49
MKT3	0.37	0.48
MKT4	0.56	0.50
MKT5	0.21	0.41
MKT6	0.33	0.47
MKT7	0.65	0.48
MKT8	0.68	0.47
MKT9	0.36	0.48
MKT10	0.42	0.50
MKT11	0.79	0.41
MKT12	0.65	0.48
MKT13	0.30	0.46
MKT14	0.44	0.50
MKT15	0.15	0.36
MKT16	0.10	0.30
MKT17	0.41	0.49
MKT18	0.65	0.48
MKT19	0.72	0.45
MKT20	0.39	0.49
MKT21	0.18	0.39
MKT22	0.18	0.38
MKT23	0.79	0.41
MKT24	0.40	0.49
MKT25	0.53	0.50
MKT26	0.59	0.49

Actual item text was not permitted and raw scores were converted using Item Response Theory as agreed to conditions in the MKT terms of use policy.

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