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Exploring Pre-Service Special and General Education Teachers' Beliefs and Attitudes in Mathematics and Learning and Teaching Mathematics

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EXPLORING PRE-SERVICE SPECIAL AND GENERAL EDUCATION TEACHERS'BELIEFS AND ATTITUDES IN MATHEMATICS AND LEARNING AND TEACHING MATHEMATICS

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ABSTRACT

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The purpose of this quantitative study was to examine and compare the beliefs and attitudes of pre-service special and general education teacher candidates regarding mathematics and the learning and teaching of mathematics and explore factors including student learning, teaching math, math rated affect (math anxiety and confidence), effectance motivation, usefulness of math, and the effect of previous teachers' perceptions. The interrelationship among these factors was explored and compared to participants' academic level and majors (i.e., special education and general) to determine whether these factors influenced the approaches pre-service teachers thought they would use when teaching math. The participants were 362 special and general pre-service teachers (elementary education and secondary math education) at all four academic levels (freshman, sophomore, junior, and senior). Statistical analysis methods employed to obtain the results included multivariate analysis of variance, chi square, and multiple linear regression.

Findings revealed statistically significantly differences in beliefs and attitudes toward mathematics among pre-service teachers across their academic majors. In comparison to the other two participant groups, special education pre-service teachers had more anxiety and less confidence in their math abilities and had the lowest mean scores in usefulness of math, effectance motivation, teacher perception, and student learning of all three participant groups.

Findings also indicated the relationships between major and planning to teach math and major and desire to teach math were both statistically significant. In this study, special education pre-service teachers were less likely to plan or want to teach math when compared to elementary and secondary math pre-service teachers.

Furthermore, findings suggested math rated affect and teacher perception could predict pre-service teachers' beliefs in student learning. Findings suggested pre-service teachers who had less math anxiety and were more confident in their math ability were more likely to believe in a constructivist approach in student learning. Finally, a significant relationship was found between pre-service teachers' beliefs in teaching math and effectance motivation, which implied pre-service teachers who had more interest and motivation toward math were more likely to believe teaching math involved constructivist practices. Implications and suggestions for future research were provided based on the results of the current study.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The need to teach mathematics effectively in the United States of America is underscored by the need to keep up with the fast-changing demands for top performing students to excel in mathematics. Knowledge and skills in mathematics are critical for success in our current global economy (National Mathematics Advisory Panel [NMAP], 2008). In spite of increased expenditures and added legislation, the United States has failed to keep pace with many other developed countries in the world in several academic areas including mathematics as reported by Hanushek, Peterson, and Woessmann (2012) in their report, "*Achievement Growth: International and U.S. State Trends in Student Performance.*" In this report, math performance data from 48 developing and emerging countries were compared. The authors found that between 1995 and 2009, 11 other countries improved their math performance scores at twice the rate of the United States.

Education policies designed to close the international gap of meeting global standards to teach mathematics have also failed. Gains achieved have been insufficient in comparison with much of the world. Although students' performances have slightly improved at the basic level compared with those of other countries like Latvia, Chile, and Brazil, U.S. students still have performed poorly in mathematics in comparison with most of their international peers (Hanushek et al., 2012). Recently, the Programme for International Students Assessment (PISA; Organization for Economic Cooperation and

Development [OECD], 2016), which measures skills such as reading, science, and math among students who are 15-years-old, released data that placed the United States 36th of 69 countries in mathematics. In addition, the Trends in International Mathematics and Science Study (TIMSS; National Center for Education Statistics [NCES], 2015) stated that 10 countries performed significantly higher than the United States in mathematics for students in the fourth grade.

To improve efforts to stay current with changing methods of teaching mathematics, the United States has undertaken substantial additional financial commitments to implement various reforms of teaching mathematics as applied to K-12 education (Hanushek et al., 2012). The National Assessment of Educational Progress (NAEP; 2009) report presented the results from math assessments across the United States and compared these state and national results with previous years. In 2015, the NAEP reported that mathematics scores were far higher than they were in 1990 with a 27 point gain in fourth grade and a 20 point gain in eighth grade. However, between 2013 and 2015, math scores were lower in fourth and eighth grades by one and two points, respectively. During this period, no student group increased its math scores in either fourth or eighth grades. Interestingly, three groups of students performed at lower levels in both fourth and eighth grades between 2013 and 2015: White students, female students, and rural students. In addition, the NAEP reported that only 40% of fourth grade students and 33% of eighth grade students performed at or above the proficient level in mathematics as demonstrated by the NAEP assessments.

Within the United States, a wide disparity exists among states in student achievement gains. Between 2013 and 2015, the NAEP (2015) reported that only three states experienced an increase in math scores among fourth graders while 30 states saw a decrease in math scores in either fourth or eighth grades or both grades. States such as Maryland, Minnesota, Delaware, North Carolina, Washington, and Hawaii reported math scores in fourth and eighth grades significantly decreased between 2013-2015. However, even in states where math scores were stable or lower, some districts made gains in either fourth or eighth grades including the District of Columbia Public Schools, the Miami-Dade districts, and the Chicago school district (NAEP, 2015).

Students with disabilities lagged behind the performance of typical students (Mazzocco & Thompson, 2005; Schulte & Stevens, 2015). This disparity in performance indicated the need to adopt practices and steps to make the process of school mathematics instruction more accessible and comprehensible to all students because all students deserve a quality education regardless of their backgrounds, personal traits, or challenges.

With the increasing diversity in classrooms across the United States, teacher preparation programs need to prepare teacher candidates to meet the needs of all students in the classroom including students from minority groups, who are English language learners (ELL), and receive special education support services. Teacher preparation programs should be designed to equip future teachers with the knowledge, skills, and resources to teach math effectively to all students and to increase the math proficiency of all students in their schools. To do so, teacher preparation programs need to address gaps in pre-service teachers' beliefs, attitudes, knowledge, and skills in mathematics.

Statement of the Problem

Special education teachers often enter their programs of study with a fear of math, which Humphrey and Hourcade (2009) reported limited these teachers' ability to provide effective instruction to their students. Fear of math, or math phobia, has been defined "as a condition characterized by feelings of panic, helplessness, paralysis, and/or mental disorganization that arises when an individual faces mathematical reasoning or calculation" (Tobias & Weissbrod, cited in Humphrey & Hourcade, 2009, p. 26). These feelings and beliefs can limit their effectiveness as classroom math teachers.

Researchers have hypothesized that many pre-service teachers hold negative beliefs toward mathematics (Carroll, 1998; Uusimaki & Nason, 2004). The U.S. educational system allows math-anxious people to major in elementary education and become teachers even though they retain a negative attitude toward and a tendency to avoid the subject (Beilock, Gunderson, Ramirez, & Levine, 2009). Noting that many elementary teachers are math-anxious females (Beilock et al., 2009), these teachers showed low levels of confidence about their abilities in mathematics, which then influenced their learning and teaching of mathematics. What teachers perceive about mathematics including their feelings and confidence, motivations, and values might correlate with their instructional practices in teaching and learning mathematics. A number of studies have confirmed that U.S. teachers adopt certain rules and follow step-by-step procedures to teach their students how to solve math problems and then assign them with more practice until they master and become skillful in procedures rather than adopting methods that emphasize the concept of understanding and encourage students to be problem solvers (Durmas & Bicak, 2006; Mewborn, 2001; Stigler & Hiebert, 1997; Stodolsky & Grossman, 1995; Wood, Cobb, & Yackel, 1991).

Moreover, there is a tendency among teachers and parents alike to believe some people simply do not "get" math, which can reduce efforts in trying to teach math or support students struggling with this subject (Lembke, Hampton, & Beyers, 2012). Negative beliefs toward mathematics prior to beginning a teacher preparation program were documented by Bruce (2004), Carroll (1998), and Uusimaki and Nason (2004). Limitations within teacher preparation programs include a lack of subject matter knowledge, little practice in using evidence-based practices in teaching mathematics, and inadequacies in understanding the needs of students with disabilities (Jackson & Neel, 2006; Maccini & Gagnon, 2006; Mastropieri, Scruggs, & Graetz, 2005). These issues, along with changes in the way math instruction is conceptualized, have led to many general and special education teachers feeling uncomfortable and unprepared to deliver mathematics education to exceptional students (Mulcahy, Krezmien, & Maccini, 2014). In addition, many teachers in the United States seem to hold more traditional or positivist beliefs about teaching mathematics that emphasizes following steps and procedures rather than understanding concepts underlying those procedures (Durmas & Bicak, 2006; Mewborn, 2001; Stodolsky & Grossman, 1995).

In recent years, the teacher-focused approach—where the teacher stands in front of the class and imparts information while students listen and presumably learn—has come into question (Mewborn, 2001). Research into more engagement by students in their learning has led to an alternative, more constructivist approach where students are more active and the teacher's role changes to one of creating and enhancing environments for increased student activity. In the constructivist classroom, students learn in a way that appreciates the pedagogical value of behavior and practices. Students' learning via this approach involves a more collaborative environment that also encourages and emphasizes using manipulatives in learning. Moreover, students realize and value the role of active learning through having real problems that relate to their lives (Anderson & Piazza, 1996). Students learn via the constructivist approach the importance of conceptualization and understanding the meaning of mathematics rather than being restricted to merely memorizing procedures and facts.

While teaching mathematics has to be established on a strong foundation of knowledge, teaching mathematics also requires other important components such as values, motivation, confidence, and enjoyment, all of which indicate positive beliefs and attitudes (Dede, 2015; Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Maasepp & Bobis, 2015; Perry, 2011; Ricco, Pierce, & Medinilla, 2010; Uusimaki & Nason, 2004; Yazici, Peker, Ertekin, & Dilmaç, 2011; Zakaria & Nordin, 2008). Furthermore, teaching mathematics effectively requires understanding that there are relationships among teaching the subject matter and the impact of teacher beliefs, instructional planning and teaching, content knowledge, and the effects of teachers' attitudes and beliefs on students' achievement (Ambrose, 2004; Cross, 2009; Rosas & West, 2011). This complex interaction of inter-relationships of a solid foundation in knowledge of mathematics with other influential factors like beliefs, attitudes and, values has led Boyd and Bargerhuff (2009) to describe teaching mathematics as special because it is profound but also flexible and adaptive; acquiring positive perceptions and beliefs in math is essential to meet the needs of students with disabilities.

In special education, there is an even greater need to develop positive perceptions and beliefs in math. Various scholars have highlighted the importance of positive beliefs and attitudes of pre-service special education teachers (Ekstam, Korhonen, Linnanmaki, & Aunio, 2017; Floyd & Rice, 2009; Lambe, 2007; Lee, 2011; Loreman, 2010; Rosas &

Campbell, 2010; Voss & Bufkin, 2011). Both pre-service special and general education teachers' beliefs need to be examined and addressed to identify factors associated with potential negative beliefs and attitudes in mathematics and how they might affect their practices and instruction for all students including students with special needs.

Purpose of the Study

The purpose of this research study was to examine and compare beliefs and attitudes of three groups of pre-service teachers including elementary and special education teacher candidates as well as secondary math teacher candidates regarding math and the learning and teaching of math. Specifically, a quantitative survey was administered to undergraduate majors in education to investigate their beliefs and attitudes about math; explore factors such as math rated affect (math anxiety and confidence), effectance motivation, and usefulness of math; and examine the effect of previous teachers' perceptions on student self-esteem and academic potential. In addition, the goal of this research was to ascertain interrelationships among these factors according to the participants' academic levels and academic majors and whether these factors influenced the approaches the pre-service teachers thought they would use when teaching math. Comparing the beliefs and attitudes of special education and general education pre-service teachers provided insight into the influence of their pre-service teacher preparation programs on their beliefs and attitudes toward mathematics. Additionally, examining pre-service teachers' beliefs and attitudes across academic levels provided information about whether pre-service teachers changed their beliefs and attitudes as they advanced in their academic program.

Rationale of the Study

A number of research studies have established that many teachers hold negative beliefs and attitudes toward mathematics (Beilock et al., 2009; Kaasila, 2007; Maasepp & Bobis, 2015; Samuelsson, 2007). These beliefs and attitudes could influence their own practices in learning and teaching mathematics (Pajares, 1992; Thompson, 1992; Wilkins, 2008). To meet the needs of their future students, pre-service teachers need to acquire a wide range of knowledge and skills to teach math concepts in ways that support student learning needs. Because pre-service teachers' attitudes and beliefs could influence their teaching practices, it was important to identify any beliefs or attitudes that could affect their mastery and use of math teaching strategies.

A body of research has concentrated on examining pre-service elementary teachers' beliefs about mathematics as they complete their teacher preparation programs (Grootenboer, 2008; Haser & Doğan, 2012; White, Way, Perry, & Southwell, 2005). However, only a few studies have explored pre-service special education teachers' beliefs and attitudes specifically in mathematics and compared those beliefs and attitudes with secondary math teachers and elementary education teachers. Teaching mathematics for all students, especially students with special needs, is a shared responsibility between special and general education teachers. However, special education teachers in some instances (exclusive or inclusive settings) are required to teach mathematics to students with special needs. Special education teachers need to know how to teach mathematics at a range of levels. Additionally, as schools increasingly move toward implementing inclusion, teaching mathematics could be considered as a dual obligation between general education math teachers and special education teachers. It is important to address and support the variety of beliefs and attitudes that exist among pre-service teachers and to ensure that all teachers learn a continuum of skills they can use to teach math to all students--those who attend the general education classroom and those who attend the special education classroom. Thus, preparing competent and effective general and special education teachers during their pre-service teacher preparation program is increasingly important.

The goal of this study was to determine whether there was a difference in the beliefs and attitudes toward math between general education and pre-service special education teachers and whether this difference influenced their beliefs in learning and teaching mathematics. Therefore, it was essential to examine these beliefs and attitudes at the teacher pre-service preparation program level in order to provide best practices and interventions to modify and change potential negative beliefs and attitudes toward mathematics including beliefs and attitudes in learning and teaching mathematics. The greatest significance of this study might lie in uncovering the beliefs and attitudes of pre-service special education teachers to teach math to students with special needs. This should be considered by educators at all levels in the education system including policy makers, university programs, and professionals in academia. Hence, findings from this study might improve pre-service preparation programs by providing information about interventions that enhance special and general pre-service teachers' positive attitudes toward mathematics while ensuring they learn the wide range of strategies and approaches they need to become successful teachers of math. Findings might also have implications for policies that address the roles of general and special education teachers regarding teaching mathematics at all levels.

Research Questions

The following research questions guided this study:

Q1 Are there differences among pre-service teachers' academic levels (freshmen, sophomore, junior, and senior) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

Q2 Are there differences among pre-service teachers' major (elementary, special education, and secondary math) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

Q3 Are there differences in pre-service teachers' plans to teach math (Yes, No) and their desirability to teach math (Desirable, Undesirable) across their major (special, elementary, secondary math)?

Q4 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness of math, math rated affect, and teacher perception) relate to their beliefs in student learning in mathematics?

Q5 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness, math rated anxiety, and teacher perception) relate to their beliefs in teaching mathematics?

Definitions of Terms

Attitude. "Refers to certain regularities of an individual's feelings, thoughts and predispositions to act towards some aspect of the environment" (Secord & Backman, 1964, p. 97).

Belief. "Internal representations to which the holder attributes truth, validity, or applicability" (Goldin, 2002, p. 61).

Confidence (ability/competency). Faith or credence "in one's ability to learn and to perform well in mathematics tasks" (Fennema & Sherman, 1976, p. 326).

Constructivist beliefs. Beliefs held by an individual (pre-service teacher) that emphasizes conceptual understanding of math ideas and stresses the importance of creativity and efforts in learning mathematics.

Constructivist teachers. Reflects attitudes of teachers who hold to a belief in students creating and building their knowledge: "Educators whose beliefs and practices allow students to construct their own knowledge through active investigation and meaningful discourse" (Vacc, cited in Capraro, 2001, p. 6).

Math anxiety. "Feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, p. 326).

Motivation (internal motivation). "The doing of an activity for its inherent satisfaction rather than for some separable consequence" (Ryan & Deci, 2000, p. 56).

Traditional beliefs. A fundamental assumption held by educators that emphasizes following step-by-step procedures, recalling information, and memorizing facts in learning mathematics. Students learn math directly from their teachers rather than through personal exploration.

Value (usefulness/utility value). Utility value is perceived when math is seen as useful for the realization of important personal goals and applicable in life.

Summary

Although most general education students have made significant gains in math since the 1990s, students with special needs continue to lag behind their peers. Teachers need to make math instruction accessible to students with a variety of needs by adopting practices and strategies that improve student learning and increase their performance. However, research has shown that many pre-service teachers have negative beliefs and attitudes when it comes to math, which could limit their effectiveness when it comes to teaching math effectively. A number of studies have asserted the importance of addressing teachers' beliefs and attitudes toward math as these beliefs and attitudes influence their own practices as well as their students' beliefs and achievements in mathematics. Thus, it is imperative to examine and identify pre-service teachers' beliefs and attitudes at the beginning of their enrollment in the program as one of the requirements of acceptance in pre-service teacher preparation programs to facilitate the best practices and interventions that might positively influence their beliefs and attitudes about math.

CHAPTER II

LITERATURE REVIEW

Along with reading and written expression, mathematics knowledge is a critical 21st century skill. A strong foundation in mathematics is a prerequisite for a number of careers, in particular those in the fields of technology, science, and engineering. Math is integrated into a number of aspects of everyday life; in addition to teaching procedural skills, math instruction fosters skills in critical thinking, communication, problem solving, and collaboration. Despite the ongoing emphasis on teaching science, technology, engineering, and math skills, students in the United States have made only small gains in their math knowledge and skills over the past 20 years and their test scores lag behind those of many of their international peers. One group in particular has consistently demonstrated low performance in math--students with disabilities.

In the following literature review, current mathematical knowledge of U.S. students is explored and factors that impacted their mathematics education are described including the educational background of math teachers, their content knowledge and pedagogical beliefs, the difference between traditional and contemporary math instruction, and how teachers' beliefs and attitudes affected their motivation to learn and teach math. Interventions that supported effective teaching practices are discussed. Throughout the literature review, research that focuses on special education teachers is highlighted as the math skills, knowledge, beliefs, and practices of these teachers are essential to the success of students with special needs.

Student Achievement in Mathematics Across the World

Several large-scale international studies reported the academic achievement of students in many countries and provided important comparative data in certain subjects across these countries including PISA (OECD, 2016) and TIMSS (NCES, 2015). In 2015, 72 OECD (2016) countries participated in PISA, which tests the knowledge and skills of 15-year-old students every three years in a range of content areas including mathematics, science, and reading. The goal of PISA is to evaluate the education systems of participating countries based on student achievement from participating countries. The TIMSS measures fourth and eighth graders' skills and knowledge in math and science and compares results from approximately 55 participating countries.

In comparison with students in East Asia such as China and Singapore, students in the United States consistently performed below average in mathematics across nations of the OECD (2016). Results from PISA (OECD, 2016) showed the United States ranked below the OECD average; the ranking fell from 29th place to 36th place between 2012 and 2015. Only 6% of 15-year-olds in the United States scored at the highest proficiency levels of five or six compared with 11% average of OECD nations. An interesting finding by PISA was that students who lived in poverty were three times more likely to attain low performance scores when compared to students from higher socioeconomic backgrounds, and immigrant students, who are often second language learners, were twice as likely to attain low performance scores when compared to their non-immigrant peers.

Compared to the OECD (2016) average, the United States also had more low-performing students and fewer high-performing students in mathematics. In addition, PISA (OECD, 2016) reported,

> The U.S. average score in mathematics literacy in 2015 was 12 score points lower than the average score in 2012 and 18 score points lower than the average in 2009, but was not measurably different than the average mathematics literacy scores in 2003 and 2006. (p. 15)

Figure 1 illustrates U.S. students' performance in math in comparison to other countries as reported by PISA.

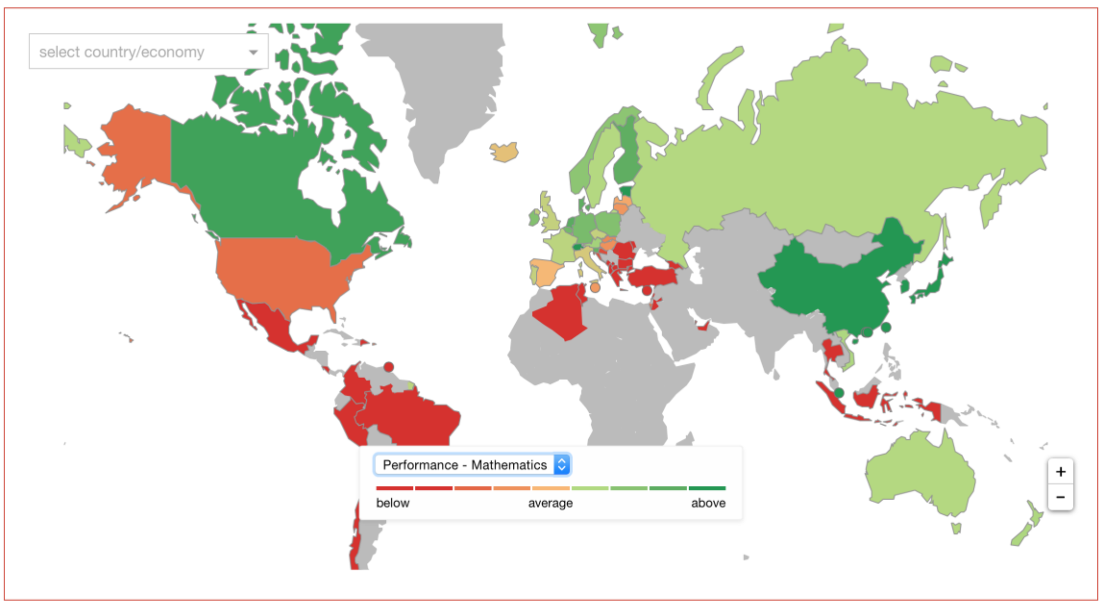

Figure 1. Performance in mathematics by country.

However, although average math scores in the United States were lower than the OECD (2016) average, there were regional and group differences. In Massachusetts, in mathematics, students scored on average 500 points above both the U.S. average (470 points) and the OECD average (490 points). It is notable that unlike most of the countries that participate in PISA (OECD, 2016) and TIMSS (NCES, 2015), the United States has a very diverse population; this might be one possible factor that has influenced student achievement and could explain the achievement gap between the United States and other OECD countries. The National Education Association (NEA; 2016) stated,

> Demographic trends and projections related to race and ethnicity, ELL status, and income level suggest that in the coming years, America's public schools will be called upon to educate an increasingly diverse student body and an increasing number of students from demographic groups that experience the largest achievement gaps. (p. 6)

National Assessment of Educational Progress

The NAEP (2015) is a large-scale, national assessment of skills and knowledge demonstrated by students in fourth and eighth grades in the United States. Subjects assessed include reading, writing, science, mathematics, geography, U.S. history, civics, economics, the arts, and technology literacy. The assessment schedule for each subject area varies; mathematics is assessed bi-annually. In 2015, NAEP reported achievement level data in math assessments for students across all 50 states including both private and public schools and discussed the gap scores within factors such as gender, race and ethnicity, ELL status, as well as students with special needs. The NAEP findings were reported at both state and national levels; in the following section, scores and percentages from the national sample are reported.

Student Achievement in Mathematics in 2015

In 2015, the average mathematics performance score of fourth grade students in the United States was 240, which was lower than their 2013 score by two points (242). In comparison to 2013, the average score of eighth grade students in mathematics assessments was two points lower than those scores in 2015. However, in 2015, the scores were higher than the scores from the earliest mathematics assessments in 1990 by 20 points (NAEP, 2015).

In 2015, 40% of fourth grade students in the United States performed at or above the proficient level while 33% of eighth grade students performed at or above proficient level in math assessments. Although these results indicated a 2% drop in math proficiency scores between 2015 and 2013 at each grade level, they had been relatively stable since 2007 (NAEP, 2015). However, within each grade, a range of proficiency levels was based on factors including gender, race, ethnicity, gender, and ELL status.

Gender, Race, and Ethnicity

Data from the NAEP (2015) showed fourth grade male students outperformed female students by two points; however, by eighth grade, both genders attained the same math score. The average scores of male and female eighth grade students at or above the proficiency level were 34% and 33%, respectively. However, large differences were evident in the math achievement scores of students based on their race and gender.

In fourth grade, math scores ranged between 224 and 259 with Black students scoring 224 points, Hispanic students scoring 230 points, White students scoring 248 points, and Asian students scoring 259 points (NAEP, 2015). This trend was repeated for eighth grade students; math scores ranged between 260 and 307 with Black students scoring 260 points, Hispanic students scoring 270 points, White students scoring 292 points, and Asian students scoring 307 points. Native Americans and Native Hawaiian/Pacific Islanders scored similarly to Hispanic students while students who identified with two races had math scores slightly below those of White students (NAEP, 2015).

Socioeconomic Status

Students who were eligible for the National School Lunch Program (NSLP), which is an indicator of the low socio-economic status of the family, received lower scores in mathematics than their peers who were not eligible for NSLP (NAEP, 2015). In fourth grade, eligible students scored 229 points while non-eligible students scored 253 points. In eighth grade, eligible students scored 268 points while non-eligible students scored 296 points. Similarly, students who had parents with a college degree scored higher than students whose parents did not have a college degree. The NAEP (2015) only reported this category for eighth grade students. Students in eighth grade whose parents did not complete high school scored 265 points while students whose parents graduated from college scored 294 points.

English Language Learners

According to NAEP (2015), "The results for students with disabilities and English language learners (ELL) are based on students who were assessed and cannot be generalized to the total population of such students" (NAEP, 2015, Grade 4). Students who were ELL scored considerably lower than their non-ELL classmates both in fourth and eighth grades and were below the proficiency level in each grade. In fourth grade, ELL students scored 218 points while their non-ELL peers scored 243 points; while in eighth grade, they scored 246 points versus the 284 points received by their non-ELL peers (NAEP, 2015).

Students with Disabilities

Unsurprisingly, students with disabilities scored lower on the math assessment than their non-disabled peers. To qualify for this category, students were either identified with a disability according to the Individuals with Disabilities Education Act (IDEA, 2004) guidelines or were protected by Section 504 of the Rehabilitation Act of 1973. It is worth noting that the majority of students with disabilities who participated in NAEP (2015) math assessments were identified with either learning disabilities (LD) or emotional disturbance (ED). Learning disabilities is the single largest category of students with disabilities, comprising approximately one third of all students identified with a disability in U.S. schools. While ED is a far smaller group of students, comprising approximately 5% of all students with disabilities, this group of students is more likely to have a Section 504 support plan and to achieve at grade level than students in other disability categories including students with intellectual or multiple disabilities. Students with disabilities in fourth grade scored 218 points versus 244 points for students without disabilities. Similarly, students with disabilities in eighth grade scored 247 points while their non-disabled peers scored 287 (NAEP, 2015).

In addition to measuring student achievement, NAEP (2015) gathered additional information to make the assessment more accurate. Therefore, teachers were asked to complete questionnaires about their educational background, additional content area training, as well as instructional practices in the content area that was assessed. The National Council of Teachers in Mathematics (NCTM; 1991, 2000) and the National Survey of Science and Mathematics Education (NSSME; Banilower et al., 2013) also gathered information about teachers who teach mathematics. In the following section, the educational background and content level background in mathematics among teachers in the United States are discussed.

Educational Background of Teachers
Who Teach Mathematics

The No Child Left Behind Act of 2001 (2002) required teachers be highly qualified in the content areas they teach. However, research suggested many elementary teachers lacked essential components such as depth understanding of math and knowledge of appropriate pedagogical practices and instructions in mathematics (Ball, Thames, & Phelps, 2008; Ma, 1999). A study by Ma (1999) compared elementary school mathematics teachers in the United States with their counterparts in China (Shanghai) in terms of math knowledge. The researcher found U.S. teachers in elementary school had far less knowledge than those in China. In addition, results indicated teachers in the United States lacked content knowledge and depth of mathematical understanding.

In 2009, NAEP gathered data on the educational background of fourth and eighth grade teachers. Results indicated 62% of fourth grade elementary school teachers had a degree in education while 36% had a different college major. While 6% of teachers had a minor or special emphasis in math, only 1% had a degree in math or math education or majored in math. In 2012, the NSSME (Banilower et al., 2013) surveyed 7,752 teachers who taught mathematics and science in schools across the United States. Results indicated while 95% of elementary school teachers had taken mathematics education content courses for elementary school teachers, less than 10% had taken college level math courses including algebra, trigonometry, calculus, probability, or statistics (Banilower et al., 2013).

While elementary school teachers are responsible for teaching a range of subjects such as science, reading, and math to the same students for the majority of their day, middle school and high school teachers often teach content specific areas such as math and science. In 2003, NAEP (2009) found that although one-third of eighth grade students were taught by teachers who had an undergraduate degree in mathematics or mathematics education, half of the students in eighth grade were taught by teachers who lacked substantial math training. However, in 2012, findings by the NSSME (Banilower et al., 2013) indicated 97% of middle school math teachers held a teaching credential and 36% had a mathematics or mathematics education background. Approximately 50% of math teachers had taken college level math courses in all or nearly all of the six areas recommended by the NCTM including algebra, trigonometry, calculus, probability, or statistics (Banilower et al., 2013).

At the high school level, the NSSME (Banilower et al., 2013) found 94% of math teachers held a teaching credential and nearly three-quarters had a college degree in mathematics or mathematics education. High school math teachers were also the most prepared to teach their content area as 95% had completed a college course in calculus and 84% had taken courses in linear algebra. Most of the high school teachers surveyed felt very well-prepared to teach fundamental mathematics, including the operations and functions of the number system and algebraic thinking, while less than one-third of teachers felt very well-prepared to teach specific topics such as discrete mathematics, statistics, and probability (Banilower et al., 2013).

Although a number of national and international large-scale surveys have included data about student achievement (PISA, TIMSS), teacher background (NAEP, NSSME), and instructional strategies (NSSME), very little data have been provided about the achievement of students with special needs and no data were found that addressed the educational background of special education teachers who provide instruction to students with disabilities. In the following section, the role of special education teachers in teaching mathematics to students with disabilities is described.

Special Education Teachers and Mathematics

Special education is a key area in the U.S. educational system that has undergone many changes and refinements since passage of the first legislation requiring that schools provide educational services for students with disabilities in 1975 (Education for All Handicapped Children Act [PL 94-142]). The IDEA (2004), the revised legislation of the PL94-142, required that students with disabilities be placed in the least restrictive educational environment that could still meet their needs (Schulte & Stevens, 2015). As a result of this requirement, many students with disabilities spend the majority of their time in regular education classrooms taught by general education teachers who have little or no training in working with students with disabilities. Schools continue to rely on special education teachers for expertise in working with students with disabilities, whereas general education teachers who often work with these students in inclusive settings have far less knowledge and experience.

The passage of No Child Left Behind Act of 2001 (2002) and the reauthorization of the IDEA (2004) required school districts employ highly qualified teachers who have full state certification, hold a license to teach, have at least a bachelor's degree, and demonstrate subject matter competence in academic subjects. In addition to these qualifications, the Council for Exceptional Children (2010) asserted that special education teachers must possess certain skills and abilities such as demonstrating mastery level of liberal arts, having pedagogical skills, and mastering appropriate academics in specialized and general curricula. The attainment of these skills and abilities is variously called proficiency or quality; sometimes the term “quality teachers” is used to describe teachers with this proficiency.

Studies examining teacher preparation programs (Bishop, Brownell, Klingner, Leko, & Galman, 2010; Brownell et al., 2009; Carlson, Lee, & Schroll, 2004; Feng & Sass, 2009; Griffin, Jitendra, & League, 2009; Seo, Brownell, Bishop, & Dingle, 2008) have specified characteristics of adequate special education training programs as these programs should provide knowledge for teaching both elementary reading and mathematics, extended preparation, applying knowledge to practices, promoting students’ achievement through interactive and explicit instructions, managing classroom effectively, and have high level engagement of students during instruction.

The attempt to define and describe what is meant by “highly qualified teachers” has resulted in substantial disagreement in defining and quantitatively measuring special education teacher quality (Brownell & Sindelar, 2008). What determines special education teacher quality is different from one researcher to another, from one program to another, and from one state to another state. Historically, policymakers and researchers have had varied opinions on the role of special education teachers. This variation in role is reflected in the existence of several models for delivering training to special education teacher candidates: categorical, non-categorical, and integrated. Each model has its own specific emphasis and components in preparing special education teachers to meet differing criteria for teacher quality. For example, in the 1970s, the categorical model required special education teachers have the knowledge of a specific disability in addition to the interventions and specific instructional approaches associated with that particular disability.

Nevertheless, teachers must master content area knowledge, employ collaboration skills, use best practice strategies, apply effective behavior interventions, and have good knowledge of subject assessments. The meaning of quality and the curriculum designed to help special education teachers acquire this quality has changed across the philosophical prospective and ideological policy of effective teaching over the past five decades. Some researchers have indicated that teachers' subject matter knowledge is an essential component in determining teacher quality (Hess, 2001; Walsh, 2001); however, other researchers stressed the concept of extensive preparation (Boe, Cook, & Sunderland, 2008; Nougaret, Scruggs, & Mastropieri, 2005; Sindelar, Daunic, & Rennells, 2004). Given the documented underachievement of students with disabilities in attaining math competency, there is an urgent need to understand what factors and characteristics comprise teacher proficiency in teaching mathematics to students with exceptionalities and special needs.

Teachers' Math Content and Pedagogical Knowledge

Research into teachers' knowledge of mathematics and reading pointed out that teachers' content knowledge and their procedures were important for instruction and students' performance (Alexander, Lignugaris-Kraft, & Forbush, 2007; Campbell et al. 2014). Numerous studies indicated teachers' academic skills are significantly correlated with students' achievement as measured by achievement tests (Campbell et al., 2014; Eide, Goldhaber, & Brewer, 2004; Wayne & Youngs, 2003). Research by Hill, Rowan, and Ball (2005) found student achievement in first and third grade is related significantly to teachers' mathematics knowledge. Other researchers added support for the importance of pedagogical content knowledge, mathematical knowledge for teaching, and teachers' subject-matter knowledge (Ball, 2000; Fennema et al., 1996). According to the NMAP (2008), research revealed teachers' content knowledge in mathematics is a critical factor related to students' achievement and success. In the following section, research into the relationship among teachers' content knowledge, their procedural knowledge, and their pedagogical beliefs is described.

In education, both content (subject matter) and procedural knowledge (pedagogical knowledge) are essential components that play important roles in students' 'understanding and achievement. According to Leinhardt and Smith (1985), content or subject matter knowledge encompasses "concepts, operations, connections among different algorithmic procedures, subset of number systems being drawn upon, classes of student errors, and curricula presentation" (p. 247) as well as understanding the relationship among all math elements including numbers and concepts (Hiebert & Lefevre, 1986). Procedural knowledge involves certain components such as computation skills, learners and teachers' class management, and the ability to perform certain actions in a certain sequence (Grossman, 1990; Hiebert & Carpenter, 1992).

In 2010, Flores, Patterson, Shippen, Hinton, and Franklin investigated the mathematical knowledge and skills among 206 in-service and pre-service special and general education teachers' mathematics skills and content knowledge as well as their perceptions of their math competency. The researchers utilized the Math Operation Test Revised (MOT-R) to measure computation skills including math operation skills from K-6 grade levels. In addition, the researchers administered the Math Concepts and Applications Test (MCAT) to measure mathematical reasoning. Findings suggested no significant differences between the performance of special and general education teachers in terms of their problem solving and computation; their average computation correct scores were 81% and 83%, respectively. However, middle school teachers performed better than elementary teachers on their computation skills. One significant problematic finding was both special and general education teachers lacked specific skills for solving and computing fraction problems (Flores et al., 2010). Chapman (2012) stated that general education teachers needed to be able to conceptualize mathematics problems and mathematics lessons in ways that fell outside of their own experiences with learning mathematics. This required practicing different approaches to problem-solving and of conceptualizing how problems would make sense to students in various ways.

Students with disabilities face unique challenges in mastering mathematics (Jitendra, George, Sood, & Price, 2010). Teaching mathematics is usually a shared responsibility between general and special education teachers, especially in teaching students with special needs. Thus, both teachers need to be equipped with sufficient knowledge and skills that capable them to teach math. Lembke et al. (2012) recommended both general and special education teachers become familiar with specific ways of identifying how students conceptualize math problems and addressing patterns and errors in student thinking including developing skills in conducting informal student interviews, analyzing error patterns in student work, and using diagnostic assessment tools such as concrete-representational-abstract evaluations.

Hunt and Little (2014) stated that teachers who provide instruction to students with special needs should understand how their students with exceptionalities conceptualize problems and concepts in math; teachers also have to be able to deliver interventions based on this understanding. Teaching mathematics in particular comprises utilization of appropriate strategies, selecting a variety of learning activities, integrating meaningful evaluations and assessments, and creating a supportive environment that stimulates a positive attitude toward mathematics (Bruce, 2004).

In an article addressing the challenges of providing math instruction to high school students with special needs, Mulcahy et al. (2014) identified the need for special education teachers to have content knowledge and proficiency to be effective in teaching mathematics. Without a strong foundation in mathematical knowledge and skills, many general and special education teachers might feel uncomfortable and unprepared to deliver math education to exceptional students. Given that teachers' content area knowledge and skills are closely related to their efficacy in teaching math skills as well as student achievement, it is vital that special education teachers are highly qualified in the content areas they teach (IDEA, 2004; Mulcahy et al., 2014; Rosas & Campbell, 2010).

In 2010, Rosas and Campbell conducted a study exploring the mathematical background and beliefs of 26 pre-service special education teachers. Approximately one quarter of the participants were general education teachers seeking an additional special education credential. Findings from this study indicated most of the participants lacked basic mathematical content knowledge. Their math course grade point average (GPA) was lower than their total undergraduate GPA. Furthermore, the majority of participants had little experience with mathematics and their experiences were generally negative. These researchers suggested when special education teachers do not have content area knowledge, they cannot be considered highly qualified teachers.

In a similar study, Maccini and Gagnon (2006) surveyed 179 secondary general and special education teachers' perceptions of (a) their knowledge of secondary math, and (b) instructional practices and assessment accommodations they used to specifically teach and assess LD and emotionally/behaviorally disturbed in problem solving tasks and basic math computation skills. Findings revealed special education teachers were less knowledgeable about higher-level math content (e.g., algebra) and were less likely to use and employ specific instructional practices and assessment accommodations. Maccini and Gagnon asserted the number of knowledge and methods courses taken by teachers contributed to and influenced the number of accommodations and instructional practices used by teachers. Additionally, these teachers often had less knowledge of or response to intervention strategies that could be implemented on an individual level or group instructional approaches that might be provided to students with unique needs (Lembke et al., 2012). Special education teachers are often less experienced in tailoring their instructional methods for special education students in mathematics compared to other subjects such as reading.

The Relationship Among Math Content, Pedagogy, and Beliefs

Research highlighted the relationship between knowledge and beliefs and the impact of this relationship on teachers' performance and practices (Campbell et al. 2014; Charalambous, 2015; Philipp, 2007; Swars, Hart, Smith, Smith, & Tolar, 2007; Wilkins, 2008). In 2007, Swars et al. investigated 103 pre-service elementary teachers' mathematics beliefs including pedagogical and teaching efficacy beliefs and teachers' mathematical content knowledge. All participants were enrolled in a teacher education program where they completed the same courses together including two mathematics methods courses taught sequentially with embedded field experiences. The researchers administered three instruments to obtain their data; two instruments, Mathematics Beliefs

Instrument and the Mathematics Teaching Efficacy Beliefs Instrument, were administered four different times during the teachers' preparation program and the Learning Mathematics for Teaching Instrument was administered when the participants finished their teaching. To measure the change in pre-service teachers' beliefs, the researcher analyzed the data with an analysis of variance (ANOVA); significant changes in their beliefs were found as they became more cognitively oriented. In addition, pre-service teachers' efficacy in teaching mathematics increased significantly during the program and there was a positive relationship between pre-service teachers' efficacy beliefs and their pedagogical beliefs as well as between their content knowledge and beliefs. Furthermore, teachers who had more mathematics content knowledge were positively affected in terms of their pedagogical beliefs, which was interpreted to mean they were more likely to believe their students could construct mathematics concepts based on their own knowledge and that mathematics skills should be taught with comprehension and understanding.

Charalambous (2015) investigated the effect of the intersection between two components--teachers' beliefs and teachers' knowledge--on teaching quality and how that impacted teachers' performance in teaching mathematics. The participants were pre-service teachers enrolled in a math course that focused on methods and math content. The course was planned in a way to help pre-service teachers improve their own skills and knowledge in math and, in turn, help them teach mathematics. The findings of this study indicated pre-service teachers' performance in mathematics was associated with their beliefs or math knowledge. Charalambous suggested teachers' knowledge and beliefs are linked to each other and this relationship is both complex and reciprocal.

Teachers’ beliefs and perceptions might be affected by the level of their knowledge, which might in turn influence their students’ achievement (Campbell et al., 2014). Although limited research investigated the relationship between teachers’ beliefs and the learning of students with difficulties in mathematics, these findings suggested the relationship between general students’ learning and teachers’ beliefs exists (Archambault, Janosz, & Chouinard, 2012; Campbell et al., 2014; Carter & Norwood, 1997) and teachers’ expectations and concerns are aligned and associated with student achievement (Schoen, Cebulla, Finn, & Fi, 2003).

Campbell et al. (2014) examined the relationship among the mathematical and pedagogical knowledge of teachers, their perceptions and beliefs, and the achievement of their students. The researchers conducted a cross-sectional study involving 259 upper elementary and 189 middle grade teachers and students from 23 districts across three states. Many instruments were utilized to obtain the data including students’ demographics, a teachers’ knowledge assessment, a beliefs and awareness survey, and an instructions survey. To analyze the data, the researchers applied a two-level hierarchical linear model and a random intercept model. The researchers found a relationship between teachers' knowledge and their beliefs and perceptions on students’ achievements wherein those teachers with higher content knowledge and pedagogical knowledge along with beliefs and awareness of student disposition and classroom awareness resulted in significantly higher student achievement and understanding of math. Campbell et al. also found the effect of upper elementary teachers’ knowledge on students’ achievement was influenced by teachers’ beliefs in teaching math (i.e., instructions that support an incremental mastery of skills), which aligned with Wilkins’ (2008) findings. The findings of Wilkins' research also indicated students who were taught by special education teachers demonstrated low proficiency in math on state achievement tests, which coincided with the findings of Feng and Sass (2009), Mulcahy et al. (2014), and Schulte and Stevens (2015). The researchers pointed to the importance of special education teachers' knowledge and how that might affect students' performance. In addition, they confirmed the significance of teachers' practices and instructions, teachers' beliefs in learning and teaching math, while considering teachers' expectations of students' mathematical practices.

Not only might students' math achievement be influenced by their teachers' beliefs and attitudes but students' beliefs and perceptions toward math might also be positively or negatively impacted. In 1997, Carter and Norwood conducted a study on in-service teachers' beliefs about mathematics and found teachers who felt positively about math transferred this excitement to their students; students in turn felt highly satisfied in terms of working hard, solving challenging math problems, and utilizing more questioning and investigating processes. In a similar study of in-service teachers' beliefs, Archambault et al. (2012) explored the relationship between teachers' beliefs and the effects of those beliefs on students' engagement and achievement in math at the secondary level from grades 7-11. They found students' academic experiences, including their achievement and engagement, were not only influenced by teachers' beliefs but could be predicted by teachers' beliefs. These research findings suggested that when teachers felt enthusiastic and capable, they transferred their enthusiasm to their students, sometimes directly by example but often more subliminally over time.

Developing Beliefs and Attitudes

Research established a relationship between teachers' content knowledge and their belief in their own efficacy as math teachers (Charalambous, 2015; Swars et al., 2007). The more content knowledge teachers had, the more likely they were to have a positive attitude toward teaching math. However, the relationship between teacher's beliefs and knowledge is reciprocal and complicated. In the following section, factors associated with the development of beliefs and attitudes among teachers is explored, starting with an examination of how we develop beliefs.

Green's Speculations on Beliefs

Green (1971) asserted that a single belief does not occur in isolation but is related to other beliefs, forming a belief system. In thinking about beliefs and belief systems, Green proposed we need to consider both what people believe and how they believe. He described three dimensions in forming and modifying beliefs: logical, psychological, and isolated protective clustering. Beliefs resting on a logical structure and reasoning still are built on what Green called a primary belief--one that cannot be traced back even further but is accepted without question. From this primary belief, derivative beliefs are drawn. Because of this reliance on a primary belief, Green calls a belief system built on a kind of logical structure a quasi-logical structure. Acceptance of a belief into a belief system rests on the understanding of a person that this belief is compatible with the existing belief system, whether or not it is truly compatible.

Another dimension Green (1971) described as a way of building belief systems is more psychological, referring to the strength and importance of those beliefs. He noted the stronger and more centrally important a belief is, the less amenable to change it is;

these beliefs might or might not have even a quasi-logical structure. As the strength and importance becomes even stronger, it moves from psychological into isolated protective clustering. Because of this, it is possible to hold some core beliefs that are logically incompatible. Often people build what Green calls a "protective shield" to ward off any challenges to these beliefs. Beliefs in this case cluster together regardless of any quasi-logical relationship and go beyond psychological strength to include conflicting and inconsistent beliefs, reflecting what Green terms isolated protective clustering.

There are several implications of Green's (1971) philosophy to the field of education. He noted there has always been a relationship between beliefs and education. Therefore, it is necessary that we understand not only what beliefs are being held but also how those beliefs are held, recognize their psychological power, and identify clustered beliefs that hold incompatible beliefs in order to improve our strategies of teaching and the activities of this teaching. In this way, we can recognize that "for some students it is an easy thing to change, while for others it is wholly beyond the realm of possibility . . . one person might be ready to doubt a belief, however the other might be unable of questioning" (Green, 1971, p. 46).

Constructing Beliefs

Explanations of individuals' beliefs and perceptions regarding mathematics are grounded in social constructivism theory. Vygotsky (1978) first articulated the precepts of this theory, suggesting knowledge and beliefs about various social phenomena are constructed in constant negotiation with other people or socio-cultural norms. Such negotiation is the underlying mechanism by which individuals create reality as they see it (Vygotsky, 1978). Crotty (1998) further expanded the meaning of social constructionism by pointing out the usual connotations of culture as customs, usages, traditions, ethics, and values of a particular group but he asserted that culture is not "the outcome of human thought and action…but is the source of human thought, …a set of control mechanisms" (p. 53). Merriam (2009) added social constructivism is based on the presumption of no single, independent, observable reality but "rather, there are multiple realities, or interpretations, of a single event" (p. 8); researchers themselves do not discover knowledge but construct its meaning. Beliefs likewise are formed and developed within a socially contracted framework. When using this constructivist theoretical framework to understand how teachers form and develop attitudes toward mathematics, it is imperative to investigate how participants' beliefs and perceptions of their own abilities are constructed and formed as a result of the participants' lived experience and other factors that might have had an influence on shaping their beliefs.

Beliefs and Attitudes

Important components in successful mathematics instruction of students, including students with special needs, are the attitudes and beliefs of teachers. According to Leder and Forgasz, (2002), beliefs and attitudes are "intrinsically related" to each other (p. 96) and in many cases, beliefs and attitudes are discussed in a cyclical manner (Pajares, 1992). However, as of yet, no single definition of belief, both within and between disciplines and fields, has been accepted. Although teachers' beliefs might influence their pedagogical choices in terms of practices and instructions that have been applied in their classes, teachers' beliefs about mathematics and how they perceive themselves as teaching mathematics has not been defined sufficiently in the literature (Philipp, 2007). According to Philipp (2007), beliefs can be "thought of as lenses that affect one's view of some aspect of the world or as dispositions toward action" (p. 259). Philipp pointed out these beliefs are more specific about the interaction between teachers and students through affecting classroom choices and practices.

Some definitions of belief were portrayed as a facet of thought. For example, Dewey (1933) defined beliefs as "something beyond itself by which its value is tested; it makes an assertion about some matter of fact or some principle or law" (p. 6), whereas Sigel (1985) described beliefs as "mental constructions of experience often condensed and integrated into schemata or concepts" (p. 351). Another definition by Rokeach (1968) identified beliefs as "any simple proposition, conscious or unconscious, inferred from what a person says or does, capable of being preceded by the phrase, 'I believe that . . .'" (p. 113). According to Rokeach, all beliefs include components such as cognitive components as knowledge, affective components capable of stimulating emotion, and a behavioral component that consists of acting upon the belief. A contemporary belief definition was provided by Goldin (2002) who articulated beliefs as "internal representations to which the holder attributes truth, validity, or applicability" (p. 61). As such, this definition was accepted in this paper.

As with the definition of beliefs, no single definition of attitude has been agreed-upon among researchers (Doob, 1967; Johnson & Howell, 2009; Secord & Backman, 1964). According to Secord and Backman (1964), attitude "refers to certain regularities of an individual's feelings, thoughts and predispositions to act towards some aspect of the environment" (p. 97). Attitude from a behavioristic psychology perspective was defined by Doob (1967) as "an implicit, drive-producing response considered socially significant in the individual's society" (p. 43). Notably, attitude is not directly observable or recognizable but can only be inferred from individual behavior. In education and particularly in the motivational domain, attitude provides clarifications and explanations of an individual's avoidance or pursuit of some educational tasks. Furthermore, attitudes are formed through experience as well as through implicit learning, and might be reflective of the person's personality. These components of attitude were also affirmed by Johnson and Howell (2009) in their acceptance of Rokeach's (1968) definitions of the three connected aspects of attitude (i.e., cognitive, behavioral, and affective).

Understanding teachers' instructional practices requires becoming familiar with how teachers construct and maintain their belief systems and attitudes (Leatham, 2006; Pajares 1992; Richardson, 1996; Thompson, 1992). This was so important that researchers called for more educational inquiry to increase understanding of current teacher practices. Leatham (2006) pointed out that each teacher embraces a specific belief system that includes a set of beliefs such as belief about learners, teachers, teaching, learning, knowledge, and curriculum:

> Of all things we believe, there are some things we 'just believe' and other things we 'more than believe – we know'. Those things we 'more than believe' we refer to as knowledge and those things we 'just believe' we refer to as beliefs. (p. 92)

Leatham (2006) discussed findings of previous research that concluded teachers' articulated beliefs could often be contradictory to some of those teachers' actions. He criticized researchers' assumptions of contradictions, postulating the contradictions might be in the eye of the researcher rather than in the eye of the teacher. Instead, Leatham proposed a lens of examining teacher belief systems with an assumption that these systems were sensible and apparent inconsistencies needed to be probed deeper for better understanding by the researcher. When Leatham examined an apparent inconsistency in his research, he found the teacher he was studying actually had another belief system the teacher felt overrode his first belief, leading to a different action that initially appeared contradictory but was actually sensible when viewed from a point of view that accepted a sensible teacher belief system. He then probed deeper to understand how that teacher made sense of an apparent contradiction.

Leatham's (2006) study was consistent with other studies that found teachers' actions did not always reflect their stated beliefs (Ambrose, 2004; Haser & Doğan, 2012; Speer, 2005). According to Haser and Doğan (2012), teachers act in specific ways depending on the beliefs they have and the conditions of specific situations. A specific situation might lead a teacher to a different action that appears to contradict an initial belief but is actually sensible when other beliefs are taken into account. Thus, teacher education programs should not only emphasize what pre-service teachers believe but should also focus on and investigate how pre-service teachers hold specific beliefs and study the conditions and situations that develop and prompt additional beliefs and different courses of action (Haser & Doğan, 2012; Leatham, 2006). In addition, it is important to study how teachers' education impacts belief clusters (Haser & Doğan, 2012). Green (1971) speculated teachers' contradictory beliefs might be located and situated in different belief clusters; sometimes one belief system might be construed as appropriate in one specific situation, leading to one action; whereas in another situation, another belief system is deemed more appropriate, leading to a different action. In addition, pre-service teachers might develop beliefs based on systemic conditions for each country or culture, such as the adopted education system that includes the nature of the curriculum and examination, to preserve a sensible belief system (Leatham, 2006).

Similarly, Haser and Doğan (2012) asserted pre-service teachers construct their belief clusters depending on their experiences in the methods courses in their education program. Consequently, researchers need to recognize dangers inherent in concluding inconsistency when further research could reveal a sensible system when understood from teachers' perspectives.

Beliefs about Mathematics

A meta-analysis study by Muis (2004) evaluated and summarized 33 studies that involved developmental approaches and cognitive constructivist and sociocultural perspectives. This researcher reviewed how personal beliefs affected math experiences. Muis found significant positive relationships between beliefs and cognition as well as between motivation and academic achievement.

During the last decades, beliefs toward mathematics have been explored in the context of teacher education (Haser & Doğan, 2012; Klein, 2001; Ma, 1999; Philipp, 2007; Van Zoest, Jones, &Thornton, 1994). Beliefs about math have the potential to influence other related educational components such as learning, teaching practices, and student achievements (Beghetto, 2008; Campbell et al., 2014; Muis, 2004; Perry, 2011). Philipp (2007) reviewed literature on teachers' beliefs about math and affect and pointed out that "from many students studying mathematics in school, the beliefs or feelings that they carry away about the subject are at least as important as the knowledge they learn of the subject" (p. 257).

Thus, focusing on pre-service teachers' beliefs and attitudes toward mathematics is a crucial aspect of education to foster legitimate reform (Ma, 1999). Numerous studies investigated pre-service teachers' beliefs about mathematics (Haser & Doğan, 2012;

Leatham, 2006; Lutovac & Kassila, 2014; Muis, 2004). In examining research about pre-service teachers' beliefs, a variety of beliefs toward mathematics were indicated including positive, negative, and mixed beliefs. Many scholars stated pre-service teachers hold positive beliefs toward mathematics (Anderson & Piazza, 1996; Durmus & Bicak, 2006; Keles, Tas, & Aslan, 2016; Trujillo & Hadfield, 1999). For example, Keles et al. (2016) investigated 227 pre-service teachers' perceptions toward mathematics. The researchers collected data by asking participants to complete sentences to solicit their responses and then categorized those responses using content analysis. The findings revealed 88.8% of their responses showed positive beliefs and perceptions toward mathematics. Similarly, Trujillo and Hadfield (1999) explored 50 pre-service elementary teachers' confidence about math and their math anxiety. The researchers administrated the Mathematics Anxiety Rating Scale and conducted interviews. Findings revealed most of the participants were confident and optimistic about teaching mathematics.

In contrast, other studies found pre-service teachers held negative beliefs and attitudes about math (Kaasila, 2007; Maasepp & Bobis, 2015; Samuelsson, 2007). These negative beliefs included a strong link to a high level of math anxiety (Barrett, 2013; Beilock et al., 2009; Haser & Doğan, 2012; Haciomeroglu, 2013; Johnson & vanderSandt, 2011), less confidence (Cardetti & Truxaw, 2014; Haser & Doğan, 2012; Swars, Smith, Smith, & Hart, 2009), and more performance-goal orientation (Harkness, D'Ambrosio, & Morrone, 2007; Phelps, 2010). For example, Samuelsson (2007) examined Swedish pre-service elementary teachers' emotions and experiences in math through interviews and letters written by pre-service teachers. The results revealed 80% of the participants had negative emotions toward mathematics. The findings also indicated these negative emotions might be due to having limited math courses in their secondary schools.

Yet a third group of researchers found pre-service teachers held mixed beliefs toward mathematics (Harkness et al., 2007; Lee & Zeppelin, 2014). By administering an autobiographical approach at the beginning of a math method course, initial findings of Harkness et al.'s (2007) research indicated a third of the pre-service teachers had mixed feelings toward mathematics as described by whether they liked or disliked the subject based on prior experiences as learners.

Most of these studies sampled general pre-service elementary teachers (Bekdemir, 2010; Lutovac & Kaasila, 2014; Wilkins, 2008) and/or secondary school teachers (Dede, 2015; Dede & Karakus, 2014). Few studies investigated pre-service special education teachers' beliefs and perceptions toward math (Harris, Pollingue, Hearrington, & Holmes, 2014; Maccini & Gagnon, 2006; Rosas & Campbell, 2010) and their self-efficacy about mathematics as a part of their beliefs and attitudes (Carlson et al., 2004). No studies were found that examined the link between teachers' beliefs (such as beliefs of the nature of math, learning, teaching, content, abilities) and their instructional practice in teaching math to students with special needs. However, given that content knowledge in mathematics is one of the variables that influence general education teachers' beliefs, especially their beliefs of their ability to teach math (Mewbron, 2001), it seemed reasonable to consider this might be similar for special educators. In the following section, the differences between constructivist and traditional approaches in math instruction are discussed and followed by two types of teachers' beliefs: beliefs in learning and beliefs in teaching math.

Traditional Versus Constructivist Approaches in Math Instruction

Traditionally, mathematics has been taught by teachers using methods where students learned to follow specific rules and procedures with an emphasis on rote learning and memorization skills (Beghetto, 2008; Cross, 2009; Fives & Buehl, 2008; Stipek, Givvin, Salmon, & MacGyvers, 2001; Thompson, 1992). Student participation was often limited to practicing procedures and asking questions about materials they did not understand. Math worksheets were the primary activity to practice memorization of abstract problems and procedures that had little or no relationship to any real-life application.

In contrast to this approach, the mathematics education reform movement called for teaching and learning mathematics based on reasoning and understanding. Educators and leaders in the NCTM (1991) asserted mathematics should be learned and taught in a variety of ways that confirm conceptualizing math concepts, reflecting a more constructivist approach rather than simply recalling specific procedures and operations. In 2000, the NCTM articulated educator standards that portrayed a new vision of math instruction that improved teachers' skills and knowledge of mathematics instruction in order to enhance students' knowledge and better equip them for the demands of the workplace. One of these standards was reasoning and proof: "Being able to reason is essential to understanding mathematics" (NCTM, 2000, p. 56). These standards emphasized the importance of teaching mathematics to students using procedures that included problem solving, conceptual understanding, reasoning, and visualizing math problems (Maccini & Gagnon, 2002; NCTM, 1991, 2000). This approach was supported by numerous research studies that recommended increasing the conceptual understanding and proficiency of students in mathematics curricula instruction (Graham, Bellert, & Pegg, 2007; Mazzocco & Thompson, 2005). While this body of research did not undermine the role of procedural knowledge, it was clear from the reviewed literature that teachers required a broader focus than merely concentrating on students' procedural knowledge to carry out accurate computations and complete traditional algorithms (Schneider, Rittle-Johnson, & Star, 2011). There was a need to increase student awareness of the concepts behind the computations and to foster reasoning and communication in mathematics education.

According to NCTM (2000), it was essential that students conceptualize mathematics ideas and principles rather than merely relying on memorizing and recalling specific procedures. As a result, teaching mathematics required a high level of math skills and the provision of effective instruction that promoted solving problem tasks (Maccini & Gagnon, 2002; NCTM, 2000). Therefore, teachers must be highly qualified and have content competency (No Child Left Behind of 2001, 2002) to determine students' success (NMAP, 2008). The NMAP (2008) called for thoroughly preparing elementary teachers to teach mathematics. Teachers' conceptual understanding involves understanding the underlining concepts and principles of mathematics, which is essential to facilitate students' math conceptual understanding (Fernandez, 2005; Ma, 1999). According to the NCTM (1991), problem-solving, mathematical reasoning, and conjecturing are endorsed and reduce the reliance on teachers as a central element in education and the adoption of memorizing procedures. Math conceptualization includes teachers' ability to understand the process of students' learning and examine their mistakes and errors to enhance their learning (Ma, 1999). Although this seems a worthy goal, it is essential to define and determine more specifically the successful characteristics of pre-service teachers.

Beliefs in Learning and Teaching Mathematics

Educational research has attempted to structure and organize the systems of teachers' beliefs in mathematics into a small sub-system that focuses on beliefs about what mathematics is and beliefs regarding how math should be learned and taught (Ernest, 1989; Thompson, 1992). The beliefs and attitudes teachers hold about mathematics and learning and teaching mathematics often impact their practice and instructional strategies (Anderson, White, & Sullivan, 2005; Archambault et al., 2012; Beghetto, 2008; Campbell et al., 2014; Carter & Norwood, 1997; Cross, 2009; Fives & Buehl, 2008; Hennessey, Murphy, & Kulikowich, 2013; Holm & Kajander, 2012; Pajares, 1992; Philipp, 2007; Potari & Georgiadou-Kabouridis, 2009; Rosas & West, 2011; Stipek et al., 2001; Wilkins, 2008; Wilson, Floden, & Ferrini-Mundy, 2001). As a result, beliefs that affect practices and instructions frame and shape learners' knowledge including critical thinking (Hennessey et al., 2013). However, some researchers in teaching mathematics speculated that what pre-service teachers believed was not necessarily illustrated in their instructional practices (Klein, 2001; Van Zoest et al., 1994). In the following section, beliefs in learning and teaching mathematics are discussed in more detail.

Learning math. A dominant view on how children should learn math emphasizes mastering certain facts and fluency and following specific procedures and methods with less attention on understanding and reasoning. Learning math by following step-by-step procedures, practicing, and memorizing rules does not guarantee understanding and conceptualizing mathematics concepts. Students need to have a chance to engage and be involved in many activities that help them gain the desired consequences (Bransford, Brown, & Cocking, 2000). Specifically, children need to have the opportunity to explore and construct their knowledge by discovery. Therefore, if educators expect students to learn math in a way that involves meaningful problems related to their lives, these educators need to provide these students with a variety of opportunities to learn math in many contexts.

The importance of conceptual understanding was confirmed by the NCTM (2000) in their publication, *Principles and Standards for School Mathematics.* One of the six principles stated, “Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge” (p. 20). In addition, the NCES (2003) defined conceptual understanding:

> Students demonstrate conceptual understanding in mathematics when they provide evidence that they can recognize, label, and generate examples of concepts; use and interrelate models, diagrams, manipulatives, and varied representations of concepts; identify and apply principles; know and apply facts and definitions; compare, contrast, and integrate related concepts and principles; recognize, interpret, and apply the signs, symbols, and terms used to represent concepts. Conceptual understanding reflects a student's ability to reason in settings involving the careful application of concept definitions, relations, or representations of either. (para. 1)

Conceptual understanding allows students to utilize their knowledge in different contexts and apply them to solve new problems. The NCTM (2000) described problem solving, reasoning and proof, communication, connections, and representation as processes necessary in learning math with conceptualizing and understanding. Conceptual understanding and learning math in constructivist ways requires students, both with and without disabilities, to engage in activates to discover new knowledge

(Woodward & Montague, 2002). It is notable that teaching mathematics for students with disabilities usually is based on direct instruction and acquiring basic skills, whereas teaching students without disabilities is founded on problem-solving and conceptual understanding (Woodward & Montague, 2002).

Examining relevant literature on mathematics learning disabilities from the fields of special education and mathematics education paints a picture of the contrasts in pedagogy in these two areas. For instance, while mathematics education primarily centers on student-focused instruction that includes the construction of understanding and knowledge by surveying and tapping into the background knowledge of the student, special education centers on task analysis as well as particular and measurable objectives (Hirsch, 2007). Such objectives often appear to focus on procedural rather than conceptual skills. The inclination of special education toward procedural pedagogy is understandable given the fact that most students with disabilities struggle with visual perception, short-term memory, auditory competence, and executive functions (Reid, 2006).

A case study by Butler, Beckingham, and Novak Lauscher (2005) explored the higher level of understanding and attitudes toward math of three eighth grade students with learning difficulties in math. The participants enrolled in a learning assistance classroom to get explicit and systematic support in math within a strategic content learning (SCL) intervention that emphasizes self-regulated and strategic learning. Results indicated that using an SCL had a positive influence on promoting self-regulated and strategic learning. Butler et al. reported, “One surprising finding was that these struggling learners, who admittedly ‘hated’ math, were positively engaged in active learning and collaborative problem solving through SCL instruction" (p. 171). The researchers also asserted that students in special education settings could be actively engaged and construct their math knowledge from instruction in mathematics supported by their teachers. Butler et al. concluded,

> One challenge is that a mainstay of empirically validated instruction in special education is the direct teaching of concepts, skills, and/or strategies. Teachers and researchers therefore struggle to articulate methods to engage students in constructive learning without compromising the explicit, systematic support that is most often recommended. (p. 158)

Students with disabilities face unique challenges in mastering mathematics (Jitendra et al., 2010). Various scholars have proposed and evaluated different strategies for addressing mathematics learning disabilities and facilitating effective instruction. From the reviewed literature, strategies to improve learning experiences of students with disabilities included self-instruction, systematic and explicit instruction, peer tutoring, visual representation, and using a concrete-representational-abstract teaching sequence (Graham et al., 2007). According to Schulte and Stevens (2015), these methods of identifying student mathematics conceptualization were important but had to be preceded by identifying students who had special needs with regard to mathematics as many inclusive instructors failed to recognize these needs despite students showing poor grades in their longitudinal study.

A study by Kroesbergen and Luit (2005) compared the effectiveness of two approaches--directed instructions (DI) and a constructivist mathematics intervention commonly known as guided instruction (GI)--for teaching multiplication to 69 students with mild mental disabilities. Findings revealed students with mild mental disabilities learned significantly in two interventions; however, these students gained much improvement in their knowledge of the basic multiplication facts when they learned by directed instructions. Kroesbergen and Luit stated the improvement made by the directed instruction group might be "explained by the fact that they were not used to such a guided instruction, because their teachers generally taught them in a more or less directive way" (p. 114). Kroesbergen and Luit articulated, "These results are promising for giving special students constructivist-based instruction… Research should be focused on making adaptations to constructivist instruction to make it more suitable for students with MMR" (pp. 114 -115).

On the other hand, much research confirmed all students including students with learning difficulties benefit from conceptual mathematics instructions that enhance students understanding in meaningful contexts (Boettge et al., 2004; Gunbas, 2015; Woodward & Montague, 2002; Zhang, Xin, & Si, 2013). It is important that teachers who teach students with special needs focus more on meaningful learning experiences that emphasize conceptualizing math concepts rather than relying merely on procedural instruction (Woodward & Montague, 2002).

An experimental design study by Gunbus (2015) examined the influence of a meaningful context (computer-based story) on 128 sixth grade students' math word problem solving achievement. The researcher presented the same math word problems in three ways: computer-based story (CS), paper-based story (PS), and isolated problem (IP). Findings revealed students who were in the CS group outperformed solving math word problems in comparison to the students in the non-story condition. Gunbus stated, "CS constructed a mental model representation of the problems, comprehended the problems well, and as a result solved the problems significantly better" (p. 91). This result aligned with other research that confirmed the importance of teaching math problems in meaningful contexts (i.e., story) rather than using traditional methods (Capraro & Capraro, 2006; Keat & Wilburne, 2009).

Similarly, Boettge et al. (2004) compared two groups of sixth grade students (total of 93 students including 17 students with special needs) on their math achievement and ability to solve problems in several learning contexts (i.e., standard word problem/ traditional text-based instruction and contextual-based problem--referred to as enhanced anchored instruction). Results indicated both groups including students with special needs improved in their ability to solve math word problems; however, students in the group that used video scenarios (video-based problem) performed better than the other group in solving math word problem and were able to transfer and apply learned skills in other situations and problems.

Teaching math. Most math instruction in the United States falls into one of two main approaches: the traditional approach that emphasizes step-by-step instruction of specific procedures that encourages students to master rules (Thompson, 1992) and the constructivist approach that engages students actively in constructing knowledge around mathematical concepts (Cross, 2009). It is notable that teachers who consider themselves responsible for transferring specific procedures and rules to their students hold traditional rather than constructivist beliefs in their teaching (Anderson & Bird, 1995; Beghetto, 2008; Cross, 2009; Fives & Buehl, 2008). The constructivist approach aligned with NCTM’s (2000) recommendations in teaching mathematics. The NCTM advocated teaching mathematics in environments that emphasize solving problems with others and motivating students to create and invent their own ways and strategies. This vision requires teachers support students' constructions in understanding math concepts and avoid the use of direct instruction and apply the exact procedures.

Teachers who adopt this constructivist approach demonstrate beliefs about learning as a whole process where their instructional decisions are informed by engaging their students' thinking (Cross, 2009) and encourage their students to be creative in their thinking rather than depending on memorizing mathematics (Beghetto, 2008). A constructivist view of learning that encompasses the idea of actively constructing knowledge and not learning passively through memorization of the rules and procedures is the fundamental basis of current reform in mathematics teaching. This view was presented by Ernest (1989) who described a model of teaching that reflected a constructivist theory of learning where teachers serve as facilitators in teaching students based on students' solving mathematics problems and on their mathematical thinking. This model was aligned with the mathematics reform movement, centering on student-focused instruction that includes the construction of understanding and knowledge by surveying and tapping into the background knowledge of students. Therefore, many scholars assert that teaching students mathematics should embrace solving problems and engaging students in activities that ensure students gain understanding, reasoning, and strategic analysis through processes of acquiring knowledge and information and incorporating discovery, creativity, and formation of meaning (Cobb, Wood, & Yackel, 1993; Thompson, 1992; Wood et al., 1991).

Another factor related to belief systems and how they affect teaching style and student outcomes relates to the presence of positive attitudes and emotions toward mathematics. Since much research has shown confidence is related to enjoyment (Stipek, et al., 1998), it was hypothesized that teachers with constructivist beliefs in teaching math were more likely to experience enjoyment. These assumptions were supported by the research findings of Stipek et al. (2001) who conducted a study that explored the relationship among 21 elementary teachers' beliefs, their instruction and practices, and student outcomes in math. These researchers hypothesized that teachers who held constructivist, inquiry-oriented math beliefs as opposed to more traditional beliefs were more likely to emphasize effort, independence, and creativity in student evaluation. The impact of the teachers' beliefs and practices on students were studied using 437 students, with assessments at the start and end of the academic year. The researchers found teachers who held inquiry-oriented beliefs about mathematics were more confident and enjoyed teaching the subject when compared to teachers who held traditional beliefs about math. In addition, the researchers reported traditional teachers' beliefs about math translated to traditional practices. Although there was no significant relationship between teachers' math enjoyment and students' math enjoyment, strong evidence indicated teachers' confidence in math was associated with students' beliefs and perceptions of their math competency, which the researchers attributed to the direct or indirect effect of modeling confidence by teachers.

Similarly, Wilkins (2008) suggested beliefs have the "strongest effect on teachers' practice" (p. 193). This researcher investigated 481 in-service elementary teachers' attitudes of mathematics, knowledge of mathematics content, and beliefs of effective instruction. Findings revealed a positive relationship between teachers' beliefs about effective instruction and practices they employed. The researcher reported teachers who believed more in inquiry-based-instruction were more likely to use inquiry-based-instruction in their classrooms; this was confirmed by other researchers (Richardson, 1996; Stipek et al., 2001; Thompson 1992). This finding aligned with the results of Pajares (1992) who documented a significant effect of beliefs on teacher's behavior and effectiveness in classrooms. The findings of Wilkins' study also revealed no significant differences between primary and upper elementary teachers' beliefs about effective instructions; both groups of teachers believed in the effectiveness of inquiry-based-instruction as they held positive beliefs in teaching math. An interesting finding was reported by Wilkins who stated, "A majority (63%) of teachers' beliefs and practices were found to be relatively consistent" (p. 149), meaning 37% of teachers' beliefs and practices were inconsistent. In addition, the researcher found primary elementary teachers utilized inquiry-based-instruction more than upper elementary teachers in their classrooms. However, Wilkins' findings revealed upper elementary teachers held more positive beliefs in math, which were associated with higher levels of math content knowledge.

Other research investigating the relationship between pre-service teachers' beliefs in mathematics and beliefs in practices supported the above findings and provided additional details and specific results (Cross, 2009; Holm & Kajander, 2012; Rosas & West, 2011). Cross (2009) examined pre-service teachers' beliefs in mathematics and how these beliefs could affect their mathematics practices. Participants of this study were five in-service high school teachers from two different schools who taught ninth grade algebra. The approach of this case study was to study the phenomenon of teacher beliefs. The study revealed teachers' beliefs about the nature of mathematics were the primary source of their beliefs in learning and teaching. Cross reaffirmed a relationship between mathematics teachers' beliefs and their classroom practices such as how they organize their classroom activities, how their students interact with each other, and how students learning is assessed. Findings indicated most of the teachers (three participants who had teaching math experience between one and three years) believed math as a subject was a set of formulas, rules, and certain procedures. Cross observed these teachers' views influenced their practices, the type of activities they used, and their students' learning. Data from observations revealed the teachers did not employ collaborative activities or involved in-group discussions or engaged in discourses with the students. Results indicated the roles of these three teachers were demonstrated as lecturing and the students' roles as receptive. Cross observed that although those teachers became involved in an intervention (on-going professional development) to help them incorporate collaborative and discourse activities and skills in their classrooms, they tended to elicit final answers in either numeric or algebraic form from their students and provided summative evaluations (either correct or incorrect) as the primary source of assessing students' performance.

In addition, Cross (2009) revealed the other two participants (who had math teaching experience of between 18 and 30 years) described math as a solving problem and thinking process and that learning math could be explored and navigated by problem situations rather than looking for the correct answers. Cross noted that even though these two participants held inquiry (constructivist) beliefs in teaching and learning math, there were some inconsistencies in their actions and instructions. One of the participants emphasized the concepts of process rather than product in teaching math and designed activities that focused on reasoning and critical thinking. The other participant's actions and practices differed in whether traditional or constructivist practices were used based on the contexts and subjects (i.e., teaching algebra by following steps; teacher-centered approach; teaching geometry needs thinking and working as group). However, both participants showed a tendency to use procedural knowledge in the computation of fractions during the interview. Similarly, Fuller (1996) examined 28 experienced elementary teachers and 26 pre-service teachers to compare their pedagogical content knowledge. The findings revealed participants with more teaching experience were more likely to have conceptual understanding in the area of whole numbers.

Holm and Kajander (2012) examined the effect of teachers' knowledge and beliefs on teaching mathematics. These researchers asked 20 pre-service elementary teachers to participate in pretest and posttest interviews at the beginning and end of a class to investigate the challenges these teachers encountered while they sought more knowledge in mathematics. Five pre-service elementary teachers were interviewed for more in-depth exploration. Holm and Kajander found pre-service teachers perceived math as a concept that relies on memorizing and recalling formulas: "All of these five pre-service teachers were unable to correctly answer a single explain question on the pretest survey of conceptual mathematics understanding of elementary concepts" (p. 16). Furthermore, there was a clear absence of confidence in terms of explaining their ways of mathematical thinking.

Factors that might mediate teachers' beliefs in teaching and learning math include students' responses and interactions during the class, subjects, and students' grade level (Anderson et al., 2005; Beghetto, 2008; Cross, 2009; Fuller, 1996). A study by Beghetto (2008) examined 176 pre-service teachers' beliefs in the role of imaginative versus memorization thinking in learning math for K-12 schooling. Findings revealed 68.5% of the participants believed the approach of teaching math depended on student grade level, asserting specific grades needed more emphasis on memorization and search for the correct answers. Pre-service teachers generally believed early elementary grades and transition grades (first, third, sixth, and ninth grades) were when students needed to focus more on memorization skills than imaginative thinking.

An interesting exception occurred in a study conducted by Anderson et al. (2005 who found an opposite relationship between the belief regarding previous experience and practices in one of the teacher-participants in their study. The researchers investigated teachers' beliefs and practices by first administering a survey about teaching practices to 162 elementary teachers in Australia. These teachers were then placed into two main groups--traditional and contemporary (constructivist)--based on the results of the survey; 4% of the participants were placed in a very traditional category, 11% of the participants were placed in a traditional category, 5% of the participants were placed in a contemporary category, 7% placed in a very contemporary category, and 73% of the participants were placed in a mixed group. Anderson et al. pointed out:

> The *traditional* teachers reported using strategies that are compatible with a transmissive style of teaching in that they frequently have students working alone, they preferred to provide detailed explanations, and most of this group frequently set exercises for skills practice. The *contemporary* teachers reported using practices that give responsibility to the students by encouraging group work, providing less initial explanation, encouraging individual recording, and allowing students to explore mathematical ideas. (p. 23)

Anderson et al. (2005) then selected a representative sample of nine teachers to reflect all groups (categories) and conducted semi-structured interviews to gather more in-depth information about beliefs, practices, and factors that influenced those beliefs.

The interviews revealed the three teachers holding contemporary views had been exposed to negative experiences in learning mathematics. Two of these three were selected for classroom observation and further discussion based on their deeper understanding and knowledge and strong beliefs about the importance within classrooms of problem solving. In general, Anderson et al. confirmed previous speculations that early school experiences of teachers impacted these teachers' subsequent behaviors and beliefs in their own teaching. One striking finding, however, was one of the two teachers who was observed and interviewed in depth was very clear that she opposed the approach she herself had been subjected to at school and had chosen more contemporary beliefs and practices she was observed implementing in her classroom. The researchers speculated this teacher desired to teach math in ways that contrasted with the way she was taught.

Fostering Positive Beliefs and Attitudes in Teaching Practices

It is possible to modify and change negative beliefs and attitudes toward math by integrating specific activities and components in teacher preparation programs. Some examples of the components include math course methods (Burton, 2012; Harris et al., 2014; Jong & Hodges, 2015; Maasepp & Bobis, 2015; Weldeana & Abraham, 2014), providing systematic and supervised teaching experiences (O'Brien, Stoner, Appel, & House, 2007), extended field experiences (Jong & Hodges, 2015; Prater & Sileo, 2002), and using activities and approaches such as autobiography and drawing (Guillaume & Kirtman, 2010; Lee & Zeppelin, 2014). These approaches have been shown to have a positive impact on special and general educators' math skills and knowledge as well as on their beliefs and attitudes (Bishop et al., 2010; Brownell et al., 2009; Carlson et al., 2004; Ernest, 1989; Feng & Sass, 2009; Griffin et al., 2009; McNeal & Simon, 2000;

Mulcahy et al., 2014; Seo et al., 2008). In the following section, promoting students' positive beliefs and attitudes toward math through constructivist math content and method courses as well as field experiences are discussed.

Math content and methods courses in teacher preparation program. Providing one or more math methods courses in education preparation programs has the potential to increase pre-service teacher knowledge and skills in math, which has been shown to positively influence teacher attitudes about mathematics (Jong & Hodges, 2015; Maasepp & Bobis, 2015). Thus, many researchers suggested including courses and programs that emphasize math conceptualization in teaching pre-service teachers (Harris et al., 2014; Jong & Hodges, 2013). Many studies indicated and emphasized the importance of providing math methods courses in education programs to change or evolve negative beliefs about mathematics; they are considered as effective interventions in teacher preparation programs (Burton & Pace, 2009; Gaspard et al., 2015; Gresham, 2009; Lutovac & Kaasila, 2014).

A study by Maasepp and Bobis (2015) investigated key factors that contributed to shifts in prospective primary teachers' mathematical beliefs. The intervention employed in their study was a mathematics content-focused course that presented mathematical content knowledge using activities such as enhanced collaboration, group work, and inquiring-based learning experiences. The intervention also focused on providing opportunities to investigate mathematics from another perspective by highlighting the history and culture of mathematics and exploring real life applications. Participants were asked to reflect on their beliefs and experiences about learning mathematics at their previous schools and at the level of university through a variety of in-class activities, i.e., discussion, and participation in projects. The findings of the study indicated the mathematics course positively influenced the prospective elementary teachers' perceptions of mathematics. The research findings also revealed the participants' beliefs of understanding mathematics and syllabus knowledge (being aware of the course content/layout) improved the teaching of prospective primary teachers.

Jong and Hodges (2015) investigated 146 pre-service teachers' attitudes toward math to see if any changes occurred in these attitudes (especially those with negative attitudes) about mathematics. In addition, the researchers investigated whether certain types of experiences in math methods coursework and/or student teaching experiences could provide an explanation of changing attitudes. The researchers administered three scales from the Mathematics Experiences and Conceptions Surveys (MECS; Jong & Hodges, 2015). The first scale (MECS-M1) was comprised of items about K-12 mathematics experiences and was administered at the beginning of math methods coursework. The second scale (MECS-M2) focused on questions about method experiences and field experiences in a way that reflected reform practices and mathematics methods; it was administered at the end of math methods coursework. The third scale (MECS-S) contained items about student teaching and was administered upon the completion of student teaching. The findings revealed significant changes in pre-service teachers' attitudes about math occurred from pre to post math methods coursework and from post mathematics methods coursework to post student teaching. Furthermore, the findings revealed the strongest predictors of changing attitudes toward math were entering attitudes, mathematics methods environment, and teachers' own K-12 experiences. Jong and Hodges concluded the mathematics methods coursework that emphasized supportive learning environment facilitated collaborative math discourse and supported all students to participate in math; paralleled with intensive field experiences, it could develop pre-service teachers' attitudes positively toward mathematics, which then were reflected in their teaching practices.

Weldeana and Abraham (2014) implemented what they termed a "history-based intervention" that utilized historically well-known problems described as "diverse, context-risk, and broad, and capable of producing cognitive conflict, thereby challenging several traditional beliefs" (p. 304). The intervention program involved writing activities and solving problems in math to measure the effect of this intervention on college mathematics pre-service teachers' perspectives and beliefs about mathematics. In their study, 63 second-year pre-service teachers participated in the semester-long study. Data collected by using pre and post questionnaires about teachers' perspectives of mathematics learning revealed 12 themes. Findings showed this intervention helped change and correct teachers' perspectives and beliefs toward mathematics.

In a study of 20 pre-service special education teachers, Harris et al. (2014) assessed the impact of a pilot summer program on participants' comfort levels in using mathematics vocabulary with students with disabilities to solve math word problems. The program was implemented within a five-week period, twice a week for one hour per day, and was replicated over three summers. Findings indicated a significant improvement in teachers' comfort levels to teach mathematics vocabulary after completion of this program. This pilot program suggested special education programs might need additional content courses in their curricula to prepare special education teachers to feel more comfortable in teaching math to students with disabilities.

Field experiences. Other researchers asserted the integration of field experiences with math courses in teacher preparation programs helped develop positive attitudes toward mathematics (Bahr, Monroe, & Shaha, 2013; Jong & Hodges, 2015; Peebles & Mendaglio, 2014; Swars et al., 2007, 2009). Many studies demonstrated pre-service teachers' participation in a preparation course positively impacted their attitudes, self-efficacy, and professional efficacy to work with students with diverse needs (Burton & Pace, 2009; Jong & Hodges, 2013). Practical experiences in education preparation programs that have incorporated as instructional tutoring are essential in preparing pre-service teachers.

In 2009, Burton and Pace examined pre-service teachers' attitudes toward mathematics in inclusive classrooms in a three-year case study that provided training through a field experience. The researchers administered a survey to three cohorts of general education pre-service teachers over the course of three years. For the first two years, participants were engaged in coursework; in their third year, they had a field experience working with students with disabilities. The pre-service teachers' attitudes about math, teaching math to students with disabilities, and self- efficacy to teach math to students with disabilities had little to no change for the first two years. However, in the third year, the participants participated in field experiences, which resulted in a positive trend in their attitudes toward teaching math to students with teaching disabilities and in the level of pre-service teachers 'confidence. Pre-service teachers reported the field experiences expanded their vision into the challenges and difficulties associated with students with special needs. The researchers confirmed that when pre-service teachers had focused field experiences and classroom knowledge, they showed positive attitudes and increased their self-efficacy. Burton and Pace concluded, "Teachers need to possess the skills and dispositions to teach a diverse group of students in inclusive settings" (p. 108). Furthermore, they pointed out that while the pre-service teachers in their study had positive attitudes toward students with special needs, they lacked skills and understanding to meet these students' needs.

Jong and Hodges (2013) explored pre-service teachers' perceptions about mathematics in three dimensions: prior schooling experiences, experience in a mathematics methods course, and how that course influenced their attitudes toward mathematics in teaching and learning. Participants consisted of 75 elementary pre-service teachers who enrolled in math method courses, the majority of whom were enrolled in field experience in the same semester. The mathematics courses methods at their program focused on the reform view of teaching math recommended by the NCTM (2000). The researchers developed two surveys that were administered at the beginning and end of the semester. The first survey consisted of four sections that assessed participants' beliefs about math including "attitude and past experiences, teaching and learning, methods course expectations, and diverse learners" (Jong & Hodges, 2013, p. 103). The second survey assessed the following: "Attitudes and practicum experiences, teaching and learning, diverse learners, and future teaching" (Jong & Hodges, 2013, p. 103). Jong and Hodges found pre-service teachers' prior schooling experiences (K-12) had an important influence on their perceptions toward math.

Furthermore, the results indicated there were strong relationships among their attitudes about mathematics, experiences in mathematics, and confidence in their mathematical ability in teaching math (Jong & Hodges, 2013). Moreover, findings suggested pre-service teachers' attitudes in learning and teaching math could be positively impacted by mathematics methods courses that emphasized mathematics reform. Interestingly, the results indicated teaching mathematics in a way that emphasized understanding of math was agreed upon or strongly agreed upon by 100% of pre-service teachers, whereas 78% agreed or strongly agreed they would teach mathematics using a procedural approach. Other findings revealed 80% of the participants agreed that during their learning of mathematics, their teachers always taught them using a traditional approach; however, they reported they would not use the same method in their future teaching. Although teacher preparation programs potentially influenced pre-service teachers' evolving and changing beliefs and attitudes toward math, other factors might have had a major effect on shaping and developing their beliefs and attitudes. In the following section, those factors are discussed in further detail.

Factors Related to Beliefs and Attitudes

A number of factors might have had an impact on the formation, development, and continued sustaining of teachers' beliefs and attitudes, which in turn affected their approach toward teaching mathematics. Personal experiences with math instruction, depth of math knowledge, understanding how math is conceptualized, and the influence of parents, teachers, and peers all play a part in developing our confidence or anxiety toward math (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006; Brownell, Ross, Colon, & McCallum, 2005; Campbell et al., 2014; Eide et al., 2004; Pajares, 1992; Peebles & Mendaglio, 2014; Voss & Bufkin, 2011). Factors such as motivation, math anxiety, and the coursework required during teacher preparation programs could all influence teachers' attitudes and beliefs about math. Factors associated with these beliefs include motivation (Muis, 2004; Perry, 2011; Ricco et al., 2010; Zakaria & Nordin, 2008), value (Yazici et al., 2011), interest (Dede, 2015; Hulleman et al., 2008), self-efficacy and confidence (Carlson et al., 2004; Perry, 2011; Ricco et al., 2010), and feelings (Maasepp & Bobis, 2015; Uusimaki & Nason, 2004; Yazici et al., 2011). In the following sections, motivation, value/usefulness, math anxiety, confidence, and prior experience are explored.

Motivation and Goals

Motivation is an important component of individual success in all aspects of life including education and especially in mathematics as motivation provides the impetus or energy that drives behavior in a particular way in certain situations (Middleton & Spanias, 1999; Ryan & Deci, 2000). Motivation cannot be observed directly; however, it can be inferred by behaviors and by examining personality components, beliefs, knowledge, skills, and abilities (Kanfer, 1990). Furthermore, individuals' motivations are influenced by their beliefs about efficacy (Bandura, 1997) and their task value (Wigfield & Eccles, 1992). According to Dweck and Elliott (1983), motivation includes many factors that determine an individual's choice of activity. Motivation is a multiphase concept that has been seen from different angles depending on purpose and situations. One distinction often made is between intrinsic motivation and extrinsic motivation (Ryan & Deci, 2000).

Intrinsic motivation, defined as engagement in an activity because it is inherently satisfying (Ryan & Deci, 2000), has been identified operationally from two perspectives or approaches. One approach experimental research utilizes to measure internal motivation is *free choice* measurement (Deci, 1971). The other common way of measuring intrinsic motivation is determined by self-report of enjoyment and interest in the task itself (Ryan, 1982).

Ryan and Deci (2000) defined intrinsic motivation as “the doing of an activity for its inherent satisfactions rather than for some separable consequence” (p. 56). They suggested intrinsic motivation to learn is inferred by engaging in learning opportunities; these learning opportunities are considered as interesting, enjoyable, or reflect an individual’s psychological needs. However, many people’s activities or behaviors occur because they are extrinsically motivated. According to Ryan and Deci, extrinsic motivation is “a construct that pertains to whenever an activity is done in order to attain some separable outcome” (p. 60). This distinction between extrinsic and intrinsic motivation is particularly significant in education as there is extensive research supporting “quality of experience and performance can be very different when one is behaving for intrinsic versus extrinsic reasons” (Ryan & Deci, 2000, p. 55). Intrinsic motivation results in a higher quality learning experience and performance and enhances creativity; whereas extrinsic motivation can also lead to resistance, resentment, low student persistence, and disinterest (Ryan & Deci, 2000).

Motivation as a force directed to completion of an activity can be seen in terms of mastery goals and performance goals. Goals that focus on learning and developing competency are defined as mastery achievement goals. Midgley et al. (2000) indicated classrooms that centered on students and provided an encouraging environment to develop intellectually and promote accomplishing tasks are mastery oriented. In addition, Dweck and Elliott (1983) proposed those with a mastery goals perspective both view and measure success in terms of the amount of effort put forth and students’ goals in learning are interpreted as valuing the task itself. Learners with mastery goals are more likely to be interested in and intrinsically motivated to learn course material. With regard to mastery goals, intrinsic motivation has emerged as a crucial element in the work of educators. In general, students with a mastery goal orientation often strive toward gaining information and mastering new skills (Dweck, 1986). Various scholars (Daniels, Frenzel, Stupnisky, Stewart, & Perry, 2013; Dweck, 1986; Pintrich, 2000) demonstrated that mastery goals lead to adaptive outcomes like persistence after failure, effort, and interest. Such learners believe that competence can be developed over time through continued practice and effort.

A study conducted by Perry (2011) investigated a mastery perspective, examining the relationship between pre-service elementary teachers' motivation for learning mathematics and their attitudes toward mathematics. Participants of the study were pre-service elementary teachers enrolled in a math course required of an elementary education certification program. A convenience sampling method was utilized to recruit 384 pre-service elementary teachers including general and special education teachers. Most of the participants were females in their sophomore and junior years who were from four state universities in the United States. The researcher administered a survey consisting of six scales. Three subscales were adopted from Patterns of Adapted Learning Scales (Midgley et al., 2000) and measured pre-service motivation (achievement goals). The other three subscales measured attitude toward mathematics and were selected from the Fennema–Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976). One encouraging finding suggested female pre-service teachers are mastery-oriented, which was interpreted to mean they desired to increase their competency by improving their skills and gaining more math knowledge. This high mastery orientation by these pre-service teachers indicated an interest in subject content, which Perry (2011) suggested had a positive association with internal motivation.

In 2010, Phelps conducted a qualitative study investigating the motivation profiles of 22 pre-service teachers concerning mathematics. Selection of the participants required that they had already completed three required mathematics courses involving numbers, operations with integers and rational numbers, as well as geometry. The required mathematics content courses addressed teaching mathematics, problem solving, establishing conceptual comprehension, and designing lesson plans based on principles of constructivist learning. Volunteers from a mathematics method course were given a survey on learning goals in relation to academic-related perceptions, beliefs, and strategies related to self-efficacy. Based on this survey, participants for the research were purposely selected to ensure the sample included a range of motivational profiles. These participants were first interviewed a month later, which was followed by a second interview after two months. The results revealed three factors (social comparisons, indirect experiences, and verbal persuasions) had potential effects on pre-service teachers' motivational profiles in math courses and impacted the growth of self-efficacy and learning goals. The findings also suggested the participants showed more interest in acquiring mastery goals, which indicated more motivational profiles. Notably, the participants also suggested career goals, which were rarely outlined in existing research, as other influences for their choices and accomplishments.

In contrast to mastery goals, performance goals emphasize the demonstration of competence (Dweck & Elliott, 1983). Students might seek to attain competence in their learning and achievement or they might have goals such as avoiding unfavorable judgments (Midgley et al., 2000). Performance goals are seen in classrooms that value abilities that reach and achieve success and emphasize completion and attainment of external rewards such as grades and prizes (Middleton & Spanias, 1999; Midgley et al., 2000).

Performance goals can also be divided into performance-approach and performance-avoidance goals (Dweck & Elliott, 1983). The authors defined the performance-approach as students' goals to seek favorable judgments of their competence. Performance-avoidance goals are viewed as students' goals to prevent unfavorable judgment regarding their abilities. According to Perry (2011), the effects of performance-avoidance goals on pre-service teachers and performance-approach goals were lower than mastery goals. In addition, Perry found the presence of performance-avoidance goals even in the presence of a high level of mastery goals still resulted in poor mathematics performance in these pre-service teachers, illustrating the powerful negative effect of performance-avoidance goals. Furthermore, the strong effect of performance-avoidance goals was associated negatively with internal motivation, academic performance, and self-efficacy. These research findings indicated a positive relationship between mastery-oriented goals and positive attitudes in mathematics among pre-service teachers, which implied an interest in improving math instruction in classrooms.

In a further investigation into the close relationship between mastery goals and intrinsic motivation and between performance goals and extrinsic motivation, Middleton and Spanias (1999) found students with extrinsic motivation were more likely to have performance goals, whereas students with internal motivation had a greater tendency toward having mastery goals. Furthermore, Middleton and Spanias and Lepper (1988) proposed that students who learned “for its own sake” held intrinsic motivation while students who sought to do their academic work to obtain rewards or avoid negative judgment held extrinsic motivation. This is of particular concern in education in that many educational activities presented to students are not designed to be intrinsically interesting, which then can lead to less value and interest seen in the subject matter (Ryan & Deci, 2000).

Value

A factor closely intertwined with motivation is the perception of value, which has been defined as the significance associated with engaging in a task (Eccles et al., 1983; Rokeach, 1973). Such perceived value of a task is determined by subjective beliefs in the capability of the task to fulfill the personal needs of the learner as well as the learner’s short-term and long-term goals. Individuals can perceive value through their own discovery or by acquiring it from sources external to the individual. For instance, a student can reach a conclusion regarding the importance and value of mathematics in one’s life by actively considering the application of math in the student’s life or by hearing about such applications from others.

Intrinsic value and utility value. Eccles et al. (1983) described several types of task values such as intrinsic value and utility value (usefulness) and considered them as important components to predict an individual’s motivation and achievement. Chouinard and Roy (2008) noted the importance of making a distinction between intrinsic and utility value. While intrinsic value is often perceived when tasks result in feelings of enjoyment, utility value is perceived when the task is seen as useful for the realization of important personal goals. In the context of education, learners often see intrinsic value in tasks that are exciting, novel, and interesting. On the other hand, tasks that benefit the individual learner in day-to-day activities or those seen as relevant for the learner's future have high utility value. In essence, learners' perceptions and beliefs of intrinsic and utility value are directly linked to task interest, persistence, and performance.

Link between utility value and achievement. An important aspect of encouraging student learning is to establish a connection between course material and their lives outside the classroom (Chouinard & Roy, 2008; Guo, Marsh, Parker, Morin, & Young, 2015). Utility value can be an important tool for assisting students in making connections between what they learned in the classroom and their individual lives. In addition, utility value can empower them during the early stages of interest development to enhance repeated engagement with subject matter over prolonged periods. Utility value can also help learners overcome initial failures and challenges through the realization that the subject material is important in their lives. The link between utility value and achievement was further supported by correlational research showing perceptions of utility value predicted effort, interest, academic choices, and performance (Eccles et al., 1983; Guo et al., 2015). Taken together, the findings of these correlational studies implied utility value might be a crucial tool educators could use in promoting motivation of students in their classrooms.

Stevenson, Lee, and Stigler (1986) pointed out the importance of investigating students' beliefs in the usefulness of mathematics because these beliefs potentially influence students' achievement and predicate students' continuing the study of math. Furthermore, Eccles (1984) articulated that perceiving mathematics and science as useful subjects is an essential factor for continued study. Similarly, Briley (2012) found teaching efficacy had a positive relationship with personal beliefs about the nature of mathematics and its usefulness. Despite the fact that most studies have examined students' beliefs in the usefulness of math (Briley, 2012; Chouinard & Roy, 2008; Gaspard et al., 2015), studies are lacking that investigate pre-service teachers' beliefs in the usefulness of math. Value in education, particularly in mathematics, is essential to enhance the environment of learning, especially considering the fact that these beliefs and values might shape their interests and motivation and, in turn, influence their future students.

Value, interest, and teaching style. Some theorists considered value as an essential component of interest (Dewey, 1913; Hidi & Renninger, 2006). However, value and interest have also been differentiated as two separate constructs where value is seen to be a situation-specific predictor of subsequent interest and performance is in contrast to interest, which refers to more general beliefs about the activity over time (Hidi & Renninger, 2006; Hulleman et al., 2008). For example, Hulleman et al. (2008) examined the role of task values and achievement goals to predict subsequent performance and interest of students in a college classroom. The findings indicated initial interest and mastery-approach goals predicted subsequent interest and these relationships were mediated by task values. In addition, utility value and performance-approach goals were found to be direct and positive predicators of actual performance measured by final grades or mastery of objectives. The utility value consequence indicated an indirect path from initial interest and mastery-approach goals to performance. The researchers elucidated that students and athletes both performed better on a task when they found their own tasks personally meaningful and useful.

Other studies investigated pre-service teachers' beliefs and values in mathematics from different perspectives (Durmus & Bicak, 2006; Yazici et al., 2011). Although mathematics is frequently perceived as value-free, these researchers found teachers did in fact hold beliefs and values in relation to mathematics. In these studies, mathematical values were viewed from the two perspectives of constructivist and positivist values. Constructive values refer to values that include openness, enjoyment, creativity, and flexibility whereas positivist values refer to teacher-centered and controlled objective-oriented styles. Durmus and Bicak (2006) developed a scale to categorize mathematical values of teachers into either constructivist or positivist; administered this scale to elementary pre-service education, mathematics, and science teachers; and found constructivist values were higher than positivist values.

Yazici et al. (2011) examined the relationship between pre-service teachers' values in mathematics and teaching anxiety in mathematics. Their research revealed pre-service teachers who held constructivist value preferences had higher mathematics teaching anxiety than those who held positivist value preferences. The researchers' explanation for this effect was constructivist teaching was perceived as more difficult in organizing learning activities than positivist teaching, which already had readily available teaching and learning activities. However, Klein (2001) hypothesized that pre-service teachers were not provided adequate training in constructivist teaching methodologies and practical applications in actual classrooms. According to Klein, pre-service teachers and students have not experienced the exploration of knowing mathematics from a perspective that emphasizes the meaning of mathematics as a social and intellectual practice. Pre-service teachers instead generally consider mathematics as tables, rules, and procedures that must be transmitted by their instructors. Klein noted pre-service teachers must be supported to learn alternative investigatory and inquiry methods and develop their skills of questioning.

Math Anxiety

Experiences of feeling tension, general nervousness or worry, or even fear in some situations where the causes might or might not be apparent are termed anxiety (Hansen, cited in Ball, 1977). According to Freud (1949), anxiety has three dimensions: "(1) a specific unpleasurable character, (2) efferent or discharge phenomena, and (3) a perception of these [the above mentioned dimensions]" (pp. 69-70). Freud furthermore articulated that anxiety is an unpleasant feeling associated with the emotion of fear perceived by an individual. Freud's writings on anxiety are just as relevant today. This phenomenon of anxiety has been shown to be associated with mathematics by both students and teachers--both in relation to the subject matter itself and to the study of mathematics (Humphrey & Hourcade, 2009; Jackson & Leffingwell, 1999).

In the area of teaching mathematics, math anxiety is defined as a cognitive and emotional fear of mathematics (Williams, 1998). Furthermore, math anxiety includes "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). Math anxiety has been portrayed and defined as emotional responses and reactions that negatively impact cognition as mathematical situations are confronted (Fennema & Sherman, 1976; Richardson &

Suinn, 1972). Math anxiety has also been described as a lack of understanding or an illogical fear of mathematics, which usually leads to avoidance of the subject (Gresham, 2004). According to Zettle and Raines (2002), math anxiety is a feeling of discomfort that appears as a result of getting involved in mathematical tasks, contributes to perceiving math as a threat to individuals' self-esteem, and produces negative attitudes about the subject.

Mathematics anxiety has been investigated widely among educators (Bursal & Paznokas, 2006; Singh, Granville, & Dika, 2002; Thompson, 1992; Zettle & Raines, 2002), confirming a relationship between pre-service elementary teachers' beliefs and math anxiety (Briley, 2012; Gresham, 2009; Swars et al., 2009). Many scholars indicated a large percentage of pre-service teachers experience high levels of math anxiety (Bekdemir, 2010; Bursal & Paznokas, 2006: Burton, 2012; Gresham, 2004; Harper & Daane, 1998; Singh et al., 2002; Sloan, Daane, & Geisen, 2001; Zettle & Raines, 2002). In particular, Bursal and Paznokas (2006) showed half of their participants (elementary per-service teachers) were significantly anxious to the point they felt unable to teach math effectively.

Conversely, those pre-service teachers who held strong beliefs about their own math abilities were more able to teach math effectively and with lower math anxiety (Briley, 2012; Haciomeroglu, 2013; Swars et al., 2007, 2009). Haciomeroglu's (2013) examination of the relationship between math anxiety and mathematics beliefs of pre-service elementary teachers showed positive beliefs and less math anxiety were associated with pre-service teachers who felt more confident in their abilities to teach math.

One effect of math anxiety is it not only affects teachers' personal performance in math but it might also negatively influence their students (Beilock et al., 2009; Bulmahn & Young 1982; Furner & Berman, 2004; Martinez, 1987; Sloan et al., 2001; Stipek et al., 2001; Zettle & Raines, 2002). In 2009, Beilock et al. conducted a study measuring the impact of teacher math anxiety on student math achievement. Seventeen female elementary teachers with an average of 13 years of teaching experience and 117 students (65 girls and 52 boys) participated in the study. The rationale for selecting only female teachers was the extremely high proportion of females to males (94%) at the early elementary level. The researchers hypothesized that math anxiety in female teachers negatively affected their female students' achievement in the subject. The researchers used the short Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972) to assess teachers' math anxiety and applied the Woodcock-Johnson III tests of achievement (Woodcock, McGrew, & Mather, 2001) to measure students' math achievement and gender ability beliefs in the first three and last two months of the academic year. Beilock and colleagues found no significant correlation between students' math achievement and teachers' math anxiety at the beginning of the year. However, by the end of the academic year, higher teachers' math anxiety corresponded with lower girls' math achievement. The researchers attributed this relationship to gender and explained that teachers' math anxiety confirmed the gender stereotype that boys are good in math and girls are not. The research findings also indicated that girls' mathematics achievements were influenced by teachers' mathematics anxiety and this effect influenced girls' beliefs in math ability and how teachers' anxiety could be transferred to students as perceptions. This study implied that elementary teachers should be aware of the impact of their own math anxiety on student performance; at the general level, teacher-training institutions and teacher preparation programs should ensure that pre-service female teachers are well prepared to overcome math anxiety. The study was well designed but its external validity was limited by the use of a small sample size of teachers and students.

Clearly, it is imperative to acknowledge teachers' negative attitudes regarding math and their math anxiety as factors that play a crucial role in shaping pre-service teachers' mathematical beliefs. These factors might generate doubt and concern regarding these teachers' beliefs in their abilities to teach mathematics effectively and whether they potentially transfer their own negative feelings onto their students; this anxiety, in turn, could affect the ways they teach mathematics (Peker, 2009; Peker & Ertekin, 2011). As a consequence, students' mathematics achievement might also be negatively impacted (Beilock et al., 2009).

Confidence

Much research has examined the inverse relationship between perceived math anxiety and confidence (Bursal & Paznokas, 2006; Gresham, 2004, 2007, 2009; Haciomeroglu, 2013; Harper & Daane, 1998; Singh et al., 2002; Sloan et al., 2001; Zettle & Raines, 2002). These studies indicated mathematics anxiety was strongly related to the lack of confidence in pre-service teachers (Bursal & Paznokas, 2006; Gresham, 2009; Harper & Daane, 1998; Sloan et al., 2001).

The relationship between high levels of math anxiety and lack of confidence was explored in a quantitative study by Bursal and Paznokas (2006). The aim of the study was to investigate 65 pre-service elementary math teachers' feelings of anxiety and their level of confidence in teaching elementary math and science. The researchers administered three surveys: the Revised-Mathematics Anxiety Survey (Plake & Parker, 1982), the Science Teaching Efficacy Belief Instrument (Deehan, 2017), and the Math Teaching Efficacy Belief Instrument (Enochs & Riggs, 2002). The results of the investigation showed an inverse relationship between math anxiety and the teachers' level of confidence. Likewise, Gresham (2009) examined mathematics anxiety and mathematics teacher efficacy in 156 elementary pre-service teachers. The findings revealed a negative relationship between math anxiety and mathematics teaching self-efficacy; pre-service teachers who had the lowest levels of math confidence were associated with the highest level of math anxiety. Similarly, Perry (2011) found pre-service elementary teachers exhibited low confidence levels in learning mathematics and negative attitudes toward mathematics, which was associated with math anxiety.

In 2012, Briley examined the relationships among personal math efficacy, beliefs about mathematics, and math teaching efficacy in pre-service elementary teachers and how these might affect teachers' confidence in solving math problems. The researcher studied a sample of 95 elementary pre-service teachers (87 females and 8 males) with a mean age of 22 years. The researcher based his study on the premise that teachers need to create a conducive environment for mathematical thinking among students by emphasizing math thinking processes rather than performance. Briley referenced Bandura's (1997) social cognitive theory in the formulation of the theoretical framework in defining teacher efficacy as the teacher's judgment of his or her own abilities to produce the desired outcomes of learning in students. In his study, Briley hypothesized that math beliefs, math self-efficacy, and math teaching efficacy have a positive relation and that math beliefs and self-efficacy positively predict math-teaching efficacy. Briley found pre-service teachers with stronger beliefs in their ability to teach math were more likely to possess stronger beliefs about mathematics and were more confident in their ability to solve math problems. Furthermore, teaching efficacy had a positive relationship with personal beliefs about the nature of mathematics and its usefulness. Briley suggested teaching efficacy was a better predictor of teacher behavior than actual capability because teacher behavior influenced how teachers used their skills and knowledge in math instruction. Just as teachers' math anxiety might be transferred to their students, so too would teachers' mathematics confidence be transmitted to their students. Supporting this claim, research indicated a strong correlation between teachers' self-confidence in math at the elementary level and their students' confidence in math and how they perceived themselves as math learners (Stipek et al., 2001).

Prior Experience

An individual's previous experiences might have a great impact in shaping a person's perceptions and beliefs. For example, pre-service teachers might have been exposed to and educated in an environment that focused on teacher-centered practices where their role as students would be to receive the information and knowledge from the instructors as the main resource. Therefore, they might be inclined to implement and apply the same methods and instructions in future teaching that included teachers assuming a dominant role in class with less focus on meaningful activities and collaborative work among students. As confirmed by Pugh, Linnenbrink-Garcia, Koskey, Stewart, and Manzey (2010), these perceptions and beliefs continue throughout later professional development.

Ernest's (1989) analytical model proposed that three components--mathematics beliefs and attitude in mathematics, mathematics content knowledge, and the teaching of mathematics--are related to teachers' practices. In this model, Ernest distinguished between two beliefs: espoused and enacted beliefs. Espoused beliefs are converted to enacted beliefs as teachers implement classroom practices. Ernest's model suggested teachers' practices and instruction are influenced by the philosophy teachers adopt regarding mathematics and are impacted by teachers' beliefs about the nature of mathematics. As a result, teachers' conceptions about learning and teaching mathematics are impacted.

Teachers' beliefs regarding mathematics and teaching mathematics are significantly affected by their own previous experiences in math and previous school experiences (Brady & Bowd, 2005; Brown & Borko, 1992; Bruce, 2004; Fennema, Peterson, Carpenter, & Lubinski, 1990; Riegle-Crumb & Humphries, 2012). What we experienced in the past might affect what we perceive and believe in our daily life (Wilkins, 2008). Considering math anxiety is a component part of negative beliefs, identifying the reasons for math anxiety have been investigated and explored by many researchers (Bekdemir, 2010; Copple, 2004; Malinsky, Ross, Pannells, & McJunkin, 2006; Uusimaki & Nason, 2004). One significant factor that affects pre-service teachers' beliefs prior to entering an education program is past learning and experience with previous teachers during their lives (Bekdemir, 2010; Fennema, Peterson et al., 1990; Jackson & Leffingwell, 1999; Riegle-Crumb & Humphries, 2012; Uusimaki & Nason, 2004), specifically their math learning experiences at the secondary level (Nicol, Gooya, & Martin, 2002; Trujillo & Hadfield, 1999). Previous negative math experience and lack of family support (Malinsky et al., 2006; Uusimaki & Nason, 2004), subject's prior experience, the attained level of formal mathematics instructions (Brady & Bowd, 2005), and teachers' perceptions of their students' ability (Fennema, Peterson et al., 1990; Riegle-Crumb & Humphries, 2012) are considered possible reasons associated with the development of students' feelings and attitudes toward math.

Pre-service teachers' experiences and interactions with their previous teachers affected their beliefs (Bekdemir, 2010; Fennema, Peterson et al., 1990; Jackson & Leffingwell, 1999; Riegle-Crumb & Humphries, 2012; Uusimaki & Nason, 2004). In 2005, Brady and Bowd examined the relationship between pre-service elementary education teachers' past experience at school and their attitudes and confidence in mathematics and how this relationship might have affected their future professional practices. The participants were 176 female and 62 male pre-service teachers from an elementary/middle school education program. The participants were either in their junior or senior academic year of their program at a Canadian university and enrolled in a required math course. The researchers utilized a survey questionnaire where attitude, confidence, past experience, and math anxiety were measured using a 5-point Likert scale. The findings revealed negative correlations between math anxiety and the highest level of formal math instruction taken by the participants in their past academic years including secondary school and their first years at the university. One third of the participants had taken little formal mathematics instruction prior their practicum and 15 participants reported concerns they had experienced with formal mathematics instruction during elementary and secondary schools. The findings also indicated a link between math anxiety and its negative effect on confidence in teaching was associated with participants' formal math instruction experiences in elementary and secondary school. Another notable finding was enjoyment of math as reported by participants declined from elementary to secondary school.

In a similar study, Bekdemir (2010) examined the level of math anxiety of 167 pre-service elementary teachers and the relationship between past experiences and their math anxiety. The findings of this research study revealed pre-service teachers had previous experiences of math anxiety with the worst experiences in grades 9-11. Moreover, previous teachers' behaviors and past teaching approaches were found to be major contributors to student anxiety.

Previous teachers' expectations and perceptions about their students' abilities as learners might influence students' beliefs and attitudes, and academic success, and might affect their future performance (Fennema, Peterson, et al., 1990; Gunderson, Ramirez, Levine, & Bcilock, 2012; Riegle-Crumb & Humphries, 2012). For example, a study by Fennema, Peterson et al. (1990) asked 38 first grade teachers to identify the most and the least successful female and male students. The authors found math teachers were more likely to overestimate male students' mathematics ability and correspondingly underestimate female students' mathematics ability. They found teachers tended to attribute male students' math success or failure due to their abilities while assuming female students' math success or failure was due to their efforts. These teachers believed male students were more independent in math and more logical and competitive in comparison to female students. These results were also supported by other research findings such as a study by Riegle-Crumb and Humphries (2012) who explored the influence of gender stereotypes on high school teachers' assessments of their students.

Findings suggested this influence caused conditional bias. Researchers using nationally representative data from the Education Longitudinal Study (Ingels et al., 2007) found significant differences in teachers' perceptions about their students' ability in math. Teachers believed White male students had higher abilities than either White female students or minority students of both genders. In addition, Riegle-Crumb and Humphries found math teachers believed mathematics was easier for White male students than it was for White female students.

Another aspect of prior experience was pre-service teachers' previous experience in learning mathematics and involvement in math activities (Bruce, 2004). Many researchers have investigated the impact of negative experiences in learning mathematics and past poor performance in mathematics upon negative beliefs about math and the development of math anxiety (Ashcraft, Krause, & Hopko, 2007; Uusimaki & Nason, 2004; Zakaria & Nordin, 2008). Uusimaki and Nason (2004) investigated possible reasons for the development of negative beliefs and math anxiety in 18 pre-service primary teachers in their third year in a teacher preparation program in Australia. Their findings suggested pre-service teachers' negative beliefs and math anxiety could be attributed in part to their prior experience in learning math. Teaching certain math concepts such as algebra, number sense, and space were the most common contributors to math anxiety.

Pre-service teachers' previous experience and knowledge in their preparation program interacted either positively or negatively with their experiences in the field (Boyd et al., 2006; Copple, 2004; Mulcahy et al., 2014). One possible negative contributor in preparation programs was the lack of being exposed to mathematics.

Mulcahy et al. (2014) found through their literature review that many special education teachers themselves often had limited classroom experience learning mathematics and demonstrated only limited math proficiency. Their findings supported those of Copple (2004) who determined other possible reasons related to math anxiety and confidence. The researcher pointed out that many universities and colleges in the United States have only minimum mathematics requirements in early education programs (generally thought to encompass preschool through age eight). Therefore, many elementary teachers pursue their professional careers without acquiring enough knowledge about math. The lack of teacher preparation and knowledge contributes to math anxiety and a lack of confidence in early education teachers.

Variables Mediated by Beliefs and Attitudes About Mathematics

Research suggested beliefs and attitudes about mathematics vary among pre-service general and special education teachers (Johnson & vanderSandt, 2011; Maccini & Gagnon, 2002, 2006; Malinsky et al., 2006). Additionally, research suggested general education teachers hold more positive beliefs toward mathematics than special education teachers (Johnson & vanderSandt, 2011; Maccini, 2002). Freshman pre-service teachers often demonstrate higher levels of math anxiety than senior pre-service teachers (Jackson & Leffingwell, 1999), while senior pre-service teachers' beliefs and attitudes about math were often more positive than were freshmen or junior pre-service teachers (Dede & Karakus, 2014; Haciomeroglu, 2013; Haser & Doğan, 2012). In the following section, studies related to mathematics beliefs and attitudes at academic program levels (freshman, sophomore, junior and senior) and academic majors (elementary education, special education, and secondary education) are explored.

Johnson and vanderSandt (2011) examined the effectiveness of two math courses --a content course and a methods course--in reducing math anxiety among freshmen and sophomore pre-service teachers in different majors: special education, deaf and hard of hearing, elementary education, and early childhood. During the freshmen year, the participants enrolled in a math content course where they were introduced to a deep understanding of math concepts including reasoning and solving problems. In their sophomore year, the participants had a math method course that examined K-5 mathematics curriculum and introduced different methods and strategies in learning and teaching including the use of technology and manipulatives. To examine the level of math anxiety, the researchers administered the Mathematics Anxiety Survey-Revised (Plake & Parker, 1982) at the beginning and the end of compulsory freshmen and sophomore math courses. Initial findings of the research indicated significant differences in math anxiety levels among pre-service teachers of different education majors at the beginning of their education program. The highest math anxiety level was found in pre-service teachers of students who are deaf and hard of hearing, whereas elementary education pre-service teachers had the lowest math anxiety levels. To evaluate the effectiveness of math content courses in minimizing math anxiety, the researchers administered the survey before and after participants completed the course. They found the math content course significantly reduced math anxiety among participants, particularly for elementary pre-service teachers. In the second year of the program and prior to entering the math methods course, the results revealed early childhood pre-service teachers had the highest level of math anxiety while elementary pre-service teachers had the lowest math anxiety level. Finally, the researchers examined the change in math anxiety for the participants who completed the survey at the beginning of the math content course and at the end of math methods course to determine the effectiveness of the two math courses. The findings indicated math anxiety was reduced for pre-service teachers of students who are deaf or hard of hearing and elementary pre-service teachers but not for early childhood or special education pre-service teachers.

Haser and Doğan (2012) investigated whether the academic level of the participants had significant differences in terms of the beliefs of pre-service elementary education teachers. In addition, the researchers examined the influence of a math methods course on changing pre-service teachers' beliefs toward mathematics. In the first phase, the researchers surveyed 25 sophomores, 36 juniors, and 39 seniors on their beliefs about mathematics prior to their first field experience. The researchers developed and administered a Mathematics-Related Belief Scale that included 38 items of mathematics nature, learning, and teaching beliefs. A one-way ANOVA revealed a significant difference in the belief scores for pre-service elementary teachers across different academic year levels. Fourth-year pre-service teachers' belief scores were significantly higher than those of second- and third-year pre-service teachers. Fourth-year pre-service teaches showed higher beliefs in the importance of using manipulatives in teaching math. The researchers suggested the positive beliefs of fourth-year students might be related to a math methods course in the third year of their education program. In the second phase of the study, 31 third-year pre-service teachers were asked to complete a questionnaire of open-ended questions and provided responses about the general purpose of teaching math, personal purposes, and the types of knowledge teachers should have in math.

Haser and Doğan (2012) considered Green's (1971) cluster system beliefs in interpreting their findings about participants' beliefs in teaching mathematics: general (formal) beliefs, personal beliefs, and beliefs about teacher knowledge for teaching mathematics. Findings revealed the third-year academic experiences in the teacher education program had a significant influence on pre-service teachers' beliefs in teaching mathematics. In addition, the researchers found an elementary mathematics education program did not impact all belief dimensions in the same way. The formal beliefs of the participants did not change much during the math methods course. In contrast, personal beliefs did change, seemed to be under construction, and were likely to be peripheral. Haser and Doğan indicated the

> participants' general and personal purposes differed considerably in terms of mathematics in daily life, thinking mathematically and student enjoyment. While daily life connection was more important for the general purposes of teaching mathematics, it was mentioned less for personal purposes. (p. 267)

Haser and Doğan confirmed Leatham's (2006) framework in which teachers' beliefs systems were sensible and personal beliefs of pre-service teachers could be influenced and enhanced through a math methods course. The researchers suggested building on formal beliefs might be achieved through strengthening personal beliefs.

Similarly, Haciomeroglu (2013) examined math anxiety and math beliefs of 301 elementary pre-service teachers at different stages in their program. Data revealed significant differences between third- and fourth-year pre-service teachers in terms of their math beliefs and math anxiety. Fourth-year pre-service teachers held more positive beliefs in teaching math and slightly higher computation anxiety than third-year students. The researcher suggested the internship at elementary school and a public employee selection exam completed by fourth-year pre-service teachers influenced both their beliefs and math anxiety. Additionally, the relationship between students' math anxiety and their feelings of confidence about their math ability and their beliefs in teaching and learning math were investigated. Findings suggested a negative relationship between pre-service elementary teachers' beliefs and math anxiety. Furthermore, positive beliefs and lower math anxiety were associated with pre-service teachers who felt more confident in their abilities to teach math, which was supported by other research (Swars et al., 2009) where math anxiety was strongly related to the lack of confidence in pre-service teachers (Harper & Daane, 1998).

Other studies indicated variables such as pre-service teachers' future instructional level (i.e., elementary, secondary) potentially influenced teachers' teaching anxiety, mathematics educational values, beliefs, and motivation (Daniels et al., 2013; Dede, 2015; Dede & Karakus, 2014; Malinsky et al., 2006; Peker, 2009, Wilkins, 2008). For example, Peker (2009) examined teaching anxiety among 173 pre-service elementary teachers and 128 pre-service secondary teachers. The researcher found elementary pre-service teachers had higher levels of math teaching anxiety and secondary pre-service teachers had lower levels of math teaching anxiety. Similarly, Dede (2015) and Dede and Karakus (2014) found secondary school teachers' beliefs about math were different and more varied than beliefs held by elementary school teachers.

In 2015, Dede examined 27 German and 33 Turkish elementary and secondary teachers' mathematics education values on four subscales: (a) theory emphasis, (b) support for concrete teaching, (c) emphasis on values in mathematics teaching, and (d) affect and cognition. Findings revealed math teachers' values differed across instructional levels of teachers and across the two nations (Germany and Turkey). In

Germany, secondary math teachers scored higher than elementary math teachers on all subscales. While in Turkey, elementary math teachers scored higher than secondary math teachers on all subscales. Across the two nations, data indicated both elementary and secondary math teachers in Germany scored higher on the following subscales: theory emphasis, support for concrete teaching, and affect and cognition. On the other hand, Turkish elementary and secondary math teachers scored higher for emphasis on values. Findings suggested elementary math teachers in both nations scored higher on the following scales: (a) theory emphasis, (b) support for concrete teaching, and (c) emphasis on values in mathematics teaching; whereas secondary math teachers in both nations scored higher on the affect and cognition in mathematics teaching scale.

Dede and Karakus (2014) investigated pre-service teachers' beliefs toward mathematics and the effect of a teacher-training program on those beliefs. The researchers recruited 173 pre-service teachers from two departments: elementary mathematics education and secondary mathematics education. Data were solicited through open-ended questions about the nature of mathematics and learning and teaching mathematics. The researchers utilized a quantitative method (content analysis) to analyze qualitative data. They found senior pre-service teachers' beliefs in learning and teaching were more positive than freshmen pre-service teachers' beliefs.

Clearly, the actions and interactions of all these variables in the formation and development of beliefs and attitudes are extremely complex. Figure 2 attempts to depict this complexity.

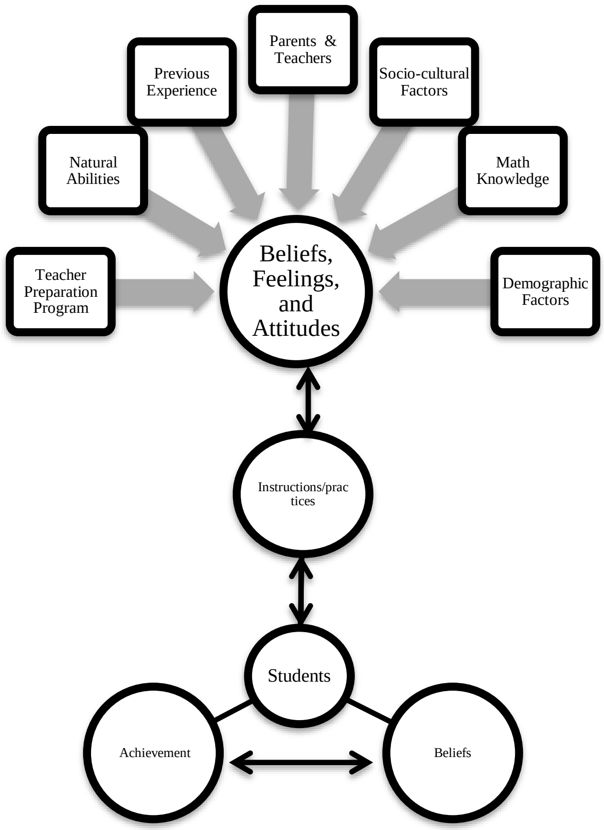

Figure 2. Representation of interactions of factors in beliefs and attitudes.

In spite of the extensiveness of research on attitudes and beliefs and their effect on teaching and learning and the development of multiple instruments with which to measure these variables, research on pre-service teachers still in their teacher preparation program remains limited. Even more limited is research studying pre-service special education teachers and almost no research could be found comparing pre-service general and special education teachers, their beliefs and attitudes, and factors involved in modifying these beliefs. This study aimed to address this need.

Summary

Although mathematics knowledge is an imperative component to success in the 21st century, current U.S. students including students with disabilities still lag significantly behind students in the rest of the world. Investigating factors behind this lag in U.S. students' math knowledge, teachers' beliefs were identified as an influence on their own performance and teaching practices, which in turn could impact their students' beliefs and achievement in math. Teachers with constructivist beliefs in teaching mathematics generally reject the approach that emphasizes mere transfer of information and memorization of math facts in favor of approaches that engage students in discovery and practical application of mathematics. In addition, they are more likely to be confident and enjoy teaching mathematics. Unfortunately, most teachers still retain a traditional, positivist, teacher-centered approach and beliefs in teaching the mechanics of mathematics.

Teaching mathematics effectively should include enhancing more mathematical skills and content and adopting effective practices and methods to foster students' learning. To promote more effective teaching of math, teachers need to be motivated and prepared to teach mathematics for all students including students with disabilities. However, many pre-service teachers hold negative beliefs about mathematics prior to entering their preparation program. Furthermore, current pre-service teaching programs do not adequately prepare teachers to teach math successfully and address negative beliefs; as a result, many pre-service teachers exit these preparation programs still holding negative beliefs, attitudes, and fears of teaching mathematics. These feelings, beliefs, and attitudes potentially influence teachers' practices and instructions, which could then be transferred to their students and impact students' beliefs and achievements.

Numerous factors contribute to the formation of these negative beliefs and attitudes in mathematics among pre-service teachers including general and special education teachers: motivation, value, anxiety, confidence, and experiences with previous teachers. Investigating these factors is an essential step to provide suggestions for educational reform in teacher preparation programs. What future teachers experienced in their past academic schooling including elementary, secondary and even more their pre-service preparation program affected and shaped their attitudes toward math, creating the potential for the development of negative beliefs and attitudes portrayed as math anxiety, less confidence and motivation, and underestimation of the value of math, which later could be transmitted to their students.

Teachers' beliefs toward mathematics could be transferred to their students' feelings and beliefs and impact their achievement. This often translates to negative beliefs in teachers being internalized by their students. Understanding how these negative beliefs are shaped and which factors are strongly associated with them is an initial step in formulating interventions to reshape these beliefs.

CHAPTER III

METHODOLOGY

The purpose of this research study was to examine and compare the beliefs and attitudes of pre-service general and special education teacher candidates regarding math and the learning and teaching of math. A quantitative survey was administered to undergraduate education majors to examine their beliefs and attitudes about math by exploring factors including student learning, teaching math, math rated affect (math anxiety and confidence), effectance motivation, usefulness of math, and the effect of previous teachers' perceptions. The interrelationship between these factors was explored and compared to participants' academic level and teaching focus (i.e., general and special education) to determine whether these factors influenced the approaches pre-service teachers thought they would use when teaching math. Comparing the beliefs and attitudes of special education and general education pre-service teachers provided insights into the influence of their pre-service teacher preparation programs on their beliefs and attitudes toward mathematics. Additionally, the examination of pre-service teachers' beliefs and attitudes across academic levels provided information about whether pre-service teachers changed their beliefs and attitudes as they advanced in their academic program.

Students with special abilities need high quality instruction to learn mathematics and are often taught by both general education teachers in inclusive settings and by special education teachers in pull-out settings. Teachers' beliefs and attitudes about math were identified in the research literature as fundamental components in successful education for teachers as well as students. This study is important because of the assumed relationship between these beliefs and attitudes about mathematics as held by teachers and their teaching practices (Beghetto, 2008; Briley, 2012; Campbell et al., 2014) as well as the relationship between these beliefs and their students' beliefs and achievement in mathematics (Archambault et al., 2012; Hennessey et al., 2013).

In this chapter, the researcher's stance is presented followed by research methods used to complete this study. The research design selected is described and the research questions are presented. Information about the setting, sampling procedure, and participants are provided and the survey instrument used in this study is described in detail. Finally, the data collection process and data analysis procedures for this study are described.

Researcher Stance

As a child in school, this researcher was fascinated with science and math. She dreamed of pursuing an education in math and was thrilled when she finally became a math and science teacher. Despite her strong belief that all students could and should be able to study math and be proficient at it, she had a great number of challenging experiences with some of the students in my math classes. The researcher addressed this by simplifying the instruction and adapting the content of lessons but soon realized that even if it seemed to help them learn specific content, this approach also limited their academic progress and development at the same time. Her fascination with math expanded to include a deep interest in how students learned math and how she as their teacher could make math a vital, useful, interesting subject to them.

Ideas that influenced and shaped her belief in the notion that what we think of our own abilities comes from the outside more than from our inner perception was found in the social constructivism theory, which was first developed by Lev Vygotsky (1978). He believed world knowledge is constructed among people and heavily influences our perception of reality. Thus, the researcher came up with an assumption that stereotypes constructed by people do not necessarily reflect reality but they influence what we perceive as reality and eventually even changes this reality.

The researcher believes access to proper education is the only key to personal advancement, success, and fulfillment. However, a common assumption is students with special needs are not able to perform above grade level math standards as well as their typical peers; the researcher disagreed with this. She believes that when the teaching environment is supportive of the needs of all students in class, all students can learn. Therefore, it is important to optimize all aspects of the learning environment--from the curriculum and materials to the instructional approaches and teaching activities. Perhaps most importantly, the researcher believes students deserve the best teachers possible who master the subject being taught, whose attitudes toward mathematics are positive and enthusiastic, who use a variety of strategies, and who believe students are capable, competent learners.

Research Design

Quantitative research design employs many types and strategies of inquiry, as experimental or non-experimental research, to reflect and view the world. In quantitative research, researchers often test theories and hypothesis to answer their research questions, transforming numeric data to statistics. The two main approaches within quantitative research are experimental and non-experimental. The goal of experimental and quasi-experimental research designs is to establish the presence of a causal relationship. Non-experimental quantitative research designs include correlation and descriptive research. A correlational design examines relationships between variables without seeking to establish cause-and-effect and can also, like descriptive designs, include observational data.

For this study, a non-experimental research design using survey research was used to examine the beliefs and attitudes of pre-service teachers toward mathematics as well as toward learning and teaching mathematics. According to Creswell (2014), surveys are commonly used to provide “a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population” (p. 13). Survey research allows the researcher to use questionnaires to collect data that yield statistical data analysis with the intention of generalizing the results from a sample to a population. In a cross-sectional study, the researcher compares the performance of two or more different groups where all the data are collected at one point in time in contrast to a longitudinal study where data are collected over a period of time. Using surveys offers researchers a number of advantages such as “the economy of the design and the rapid turnaround in data collection” (Creswell, 2014, p. 157). Surveys are generally used to collect extensive amounts of data from a large sample; therefore, researchers can quickly gather demographic data and obtain comparable information from a large sample.

In the current study, a cross-sectional survey was used to obtain data. The particular instrument used in this study allowed numerical representation of data as well as subsequent statistical analysis of emerging patterns within subscales or between subscales to identify general trends and patterns with the population of interest. By using a survey approach, the researcher was able to elicit information such as attitudes that are difficult to measure using observational methods (McIntyre, 1999).

Research Questions

The following research questions were developed to guide this study:

Q1 Are there differences among pre-service teachers' academic levels (freshmen, sophomore, junior, and senior) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

Q2 Are there differences among pre-service teachers' major (elementary, special education, and secondary math) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

Q3 Are there differences in pre-service teachers' plans to teach math (Yes, No) and their desirability to teach math (Desirable, Undesirable) across their major (special, elementary, secondary math)?

Q4 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness of math, math rated affect, and teacher perception) relate to their beliefs in student learning in mathematics?

Q5 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness, math rated anxiety, and teacher perception) relate to their beliefs in teaching mathematics?

Participants

Participants in this study were undergraduate students enrolled in one of three teacher preparation programs at a university: elementary education, special education, or secondary math education. Students represented all academic levels (freshmen, sophomore, junior, and senior) and ranged in age between 18 and 22 years.

Setting

The current study was conducted at one public university in the state of Colorado. This university serves approximately 12,260 undergraduate and graduate students from different disciplines/programs and degrees in six different colleges. The College of Education and Behavioral Sciences has an enrollment of 3,014 students of which 1,548 are undergraduate students. During 2016, undergraduate student enrollment in special education, elementary education, and secondary math education programs was 198, 532, and 121, respectively. This study was conducted on campus in a neutral setting (a classroom or study carrel at the library).

Sampling Procedure

A convenience sampling method was utilized to recruit participants for this study. The researcher chose this sampling type to obtain the sample from the most available environment. Convenience sampling is one type of nonrandom or nonprobability sampling. Creswell (2013) stated convenience sampling is used when the participants or the population of interest is within an immediate reach for research purposes. All sampling methods have advantages and disadvantages. The main advantages of convenience sampling include affordability and ease of access to participants. Although the sample population of this study needed to meet specific inclusion criteria such as academic levels and academic majors, the sample of the target population should meet other criteria such as easy accessibility, availability in certain time, and willingness to participate.

The main disadvantage to convenience sampling is the sample might be biased when compared to the target population, thus limiting the generalizability of the study. In addition, this type of sampling might cause outliers in the results because of the possibility of high selection of participants with unique views or experiences. It is notable that by choosing this type of sampling methods, there is risk in collecting poor quality data.

Sample Size

To ensure acceptable and sufficient power for statistical analyses, the researcher conducted a prior power analysis to determine an appropriate sample size for this study. Due to the absence of effect size information from previous studies, the researcher valued the reasonable percentage for the study based on Cohen's (1988) suggestion and eta square criteria. Therefore, the researcher applied G* Power in the research-consulting lab in the College of Education and Behavioral Science. Since two different types of data analysis were used, multivariate analysis of variance (MANOVA) and multiple linear regression, two separate G* Power analyses were administered. For the MANOVA, the researcher applied the following criteria: (effect size = 0.06), (α = .05), (1-β= 0.85), (number of groups = 3), (response variables= 6). The results indicated an *N* of 168 or greater would be an adequate sample size to ensure sufficient power for the quantitative analysis. On the other hand, for multiple linear regression, the following criteria were used: (effect size = 0.15), (α = 0.05), (1-β= 0.85), (number of predictors = 4). The results indicated 95 or greater would be an adequate sample size of participants to ensure sufficient power for this particular quantitative analysis.

Instrumentation

In the current study, the instrument was adapted from three existing surveys: the Fennema-Sherman Mathematics Attitudes Scales (FSMAS; Fennema & Sherman, 1976), Fennema-Sherman Mathematics Attitudes Scales--Short Form (FSMAS-SF; Mulhern & Rae, 1998) and Mathematics Beliefs Scales (MBS; Capraro, 2001). Explanations of these instruments are provided in the following paragraphs. In addition, the current survey instrument is described in detail. Information about the subscales related to beliefs and attitudes is presented, followed by a description of the pilot study, which was used to further adapt and refine the instrument for the purpose of the current study.

Fennema and Sherman Mathematics Attitudes Scales

The FSMAS (Fennema & Sherman, 1976) is one of the most popular and enduring instruments in education that measures attitudes toward mathematics. The FSMAS is composed of nine sub-scales: attitude toward success in mathematics, mathematics as a male domain, mother, father, teacher's perception, confidence in learning mathematics, mathematics anxiety, effectance motivation in mathematics, and usefulness of mathematics. The FSMAS was developed to measure secondary students' attitudes and beliefs in mathematics. Each sub-scale can be implemented and used individually as a complete instrument or as a set of more than one sub-scale (Alexander & Martray, 1989; Drisko, 1993; Iben, 1991; Sherman, 1982). The FSMAS has been administered as a combined package to high school students with the exception of the math anxiety scale. Fennema-Sherman (1976) stated, "Anxiety Scale was not used since it correlated .89 with Confidence Scale. However, some researchers are interested in anxiety as a construct" (p. 8). Factor analysis and split-half reliabilities for each sub-scale were obtained.

Many researchers have adapted and modified the FSMAS for different age groups and subject content (Sherman, 1982; Stricker, Rock, & Burton, 1993). Melancon, Thompson, and Becnel (1994) determined the instrument's factorial validity based on a sample of elementary school teachers, which was not a typical demographic group for this type of survey. Several studies adopted a shorter version of the FSMAS (Johnson, 1984; Mulhern & Rae, 1998; Sachs & Leung, 2007; Tapia, 1996) and developed a new version of four factors that could be applied for all subjects and grade levels of the secondary mathematics curriculum (Tapia & Marsh, 2004).

Shortened Form of Fennema and Sherman Mathematics Attitudes Scales

Mulhern and Rae (1998) developed a shortened version of the FSMAS-SF. The shortened form was developed based on data obtained by measuring 196 Irish students' attitudes toward mathematics from two secondary schools. Reliability and validity evidence were obtained by estimating internal consistency coefficients and conducting exploratory factor analysis. "Internal consistency estimates of the reliability of scores on the whole scale and each sub-scale for both the original and the short version were favorable, with alpha coefficients rating from 0.79 to 0.96" (Mulhern & Rae, 1998, p. 295). As a result, items were reduced to 51 items included in six subscales of the FSMAS-SF: (a) Mathematics-Rated Affect scale (included Anxiety and Confidence scales (nine items), (b) Parent's Attitudes scale (nine items) (included Father's Attitudes and Mother's Attitudes scales), (c) Usefulness scale (included eight items from the Usefulness scale and one item from the Motivation scale), (d) Male Domain scale (nine items), (e) Success scale (nine items), and (f) Teacher scale (six items). Mulhern and Rae concluded, “No clear distinction could be made in either study between the Mother’s Attitudes and Father’s Attitudes scales or between the Anxiety and Confidence scales, and no single factor was clearly associated with the FSMAS Effectance Motivation scale” (p. 305). However, Mulhern and Rae suggested the subscales used by Fennema and Sherman (1976) might not actually be measuring what the authors intended to measure.

Mathematics Beliefs Scales

Capraro (2001) constructed the MBS based on the Mathematics Beliefs Instrument developed by Fennema, Carpenter, and Loef (1990). The MBS consists of three subscales: (a) Student Learning, (b) Stage of Learning and (c) Teacher Practices; six items are used to measure each subscale. Factor analysis was conducted and coefficient-alpha reliability was obtained ($\alpha = 0.86$). As a result, three subscales were constructed: (a) Children Learning, (b) Teaching Mathematics, and (c) Curriculum (six items for each). A 5-point Likert scale used in the MBS ranged from *strongly agree* to *strongly disagree*. The higher the score was, the stronger the participants’ beliefs on constructivist orientation (more cognitively aligned). In addition, a higher score also indicated beliefs that children learn mathematics through constructing their own knowledge and the teacher’s role as a facilitator who helps children explore and investigate mathematics. A lower score indicated beliefs that students receive and learn mathematics concepts and knowledge directly from their teachers.

The Current Instrument

The instrument used in the current study was divided into two parts. The first part included demographic information and personal experience with math while the second part included subscales related to beliefs and attitudes.

Demographic information. Information gathered for the demographic section included questions regarding gender, academic major, educational background, ethnicity, overall grade point average (GPA), the score on the math section of the SAT and/or ACT, and the highest-level of mathematics course taken.

Scales related to beliefs and attitudes. The second part of the instrument consisted of questions related to the six major factors of this study: student learning, teaching mathematics, math anxiety-confidence in mathematics (mathematics-rated affect scale), effectance motivation, usefulness of math (value), and teacher perception.

Four subscales were adapted and modified from the FSMAS and FSMS-SF (Fennema & Sherman, 1976; Mulhern & Rae, 1998) to investigate participants' attitudes toward mathematics. Each scale included a different number of items. Specifically, the math anxiety and confidence in mathematics scale was considered as one scale (mathematics-rated affect scale) and included nine items: five items for math anxiety and four items for confidence. The teacher perception scale consisted of six items. Both the math anxiety-confidence and teacher perception scales were adopted from Mulhern and Rae (1998). Effectance motivation and usefulness scales consisted of 12 items each and both scales were adopted from Fennema and Sherman (1976).

The other two scales were adapted from the MBS (Capraro, 2001) to examine participants' beliefs in learning and teaching mathematics: (a) beliefs on how students learn mathematics, and (b) beliefs in the ways and methods of teaching mathematics. The MBS instrument consisted of six items for each scale (three scales). The order of MBS items was distributed and spread out across the three factors. The coefficient alpha reliability of the scores on the 18 item beliefs scale was .86. Two scales, student learning and teaching in math with a total of 12 items, were included in the instrument used in the current study.

The current instrument used in this study is called the Pre-Service Teacher Beliefs and Attitudes in Mathematics (PSTBAM). The final version of the PSTBAM has 51 items. Each scale is described in detail as follows.

1. Mathematics-Related Affect scale. This scale consists of two factors, math anxiety and confidence, due to their correlation (Fennema & Sherman, 1976; Mulhern & Rae, 1998; Tapia & Marsh, 2004).
   a. Math anxiety items**.** Measures "feelings of anxiety, dread, nervousness and associated bodily symptom related doing mathematics" (Fennema & Sherman, 1976, p. 326). In a study by Mulhern and Rae (1998), the Cronbach's alpha of 0.90 suggested scores in a sample of 196 Irish secondary students were internally consistent.
   b. Confidence items. Measures "confidence in one's ability to learn and to perform well in mathematics tasks" (Fennema & Sherman, 1976, p. 326). In a study by Mulhern and Rae (1998), the Cronbach's alpha of .91 suggested scores in a sample of 196 Irish secondary students. were internally consistent
2. Teacher Perception scale. This scale measures "students' perceptions of how their teachers feel about them as learners" (Fennema & Sherman, 1976, p. 326). In a study by Mulhern and Rae (1998), the Cronbach's alpha of 0.83 suggested scores in a sample of 196 Irish secondary students were internally consistent.

3. Effectance Motivation scale. This scale measures "effectance as applied to mathematics" and "interest or enjoyment of mathematics" (Fennema & Sherman, 1976, p. 326). In a study by Fennema and Sherman (1976), the Cronbach's alpha of 0.87 suggested scores in a sample of high school students were internally consistent.
4. Usefulness of Math scale. This scale, as described by Fennema and Sherman (1976), was "designed to measure students' beliefs about the usefulness of mathematics currently, and in relationship to their future education, vocation, or other activities" (p. 326). The reliability estimate for scores was .88 in a sample of high school students. According to Fennema and Sherman, a relationship was found between usefulness of math and math learning as well as between usefulness of math and gender.
5. Student Learning scale. This scale measures how individuals learn mathematics (Capraro, 2001).
6. Teaching Mathematics scale. This scale measures teachers' beliefs about how they should teach mathematics, reflecting their approaches whether traditional or constructivist (Capraro, 2001).

Validity and Reliability

According to Fennema and Sherman (1976), content validity was established for each sub-scale by distributing the survey to other professionals in the field. Each respondent reviewed the items independently to verify the validity for each item. However, several researchers questioned the integrity of the score of the instrument (O'Neal, Ernest, McLean, & Templeton, 1988) as well as its reliability and validity

(Suinn & Edwards, 1982). To obtain the final version of FSMAS-SF, Mulhern and Rae (1998) applied factor analysis with a minimum criterion of .40. Capraro (2001) used the instrument to measure beliefs in learning and teaching math among 54 senior pre-service teachers and 123 in-service teachers: "The cutoff used for saliency was variables with pattern/structure coefficient greater than 0.30" (p. 11).

Since this survey was developed based on existing instruments (the FSMAS, the FSMAS-SF, and the MBS), it was essential to determine the reliability of scores from respondents on each scale. According to Fennema and Sherman (1976), split-half reliability coefficients were used to determine the reliability of the scores from FSMAS. However, other studies used Cronbach's alpha instead (i.e., Mulhern & Rae, 1998). The average consistency coefficient for the FSMAS and the FSMAS-SF was above 0.8 on subscale scores in studies of high school students, which indicated rather high internal reliability of the scores from these items in previous studies. Capraro (2001) distributed the MBS, which measures beliefs in learning and teaching math, to two samples: in-service teachers and pre-service teachers. The reliability estimates for scores on the MBS were 0.68 for 123 in-service teachers and 0.86 for 54 pre-service teachers. For the current study, the process used to determine content validity and the reliability of the PSTBAM is described in detail as follows.

Content validity. Creswell (2014) described content validity: "items measure the content they were intended to measure" (p. 206). The scales used for the current instrument (the PSTBAM) were adapted from existing instruments. The researcher made minor changes to these items including checking the internal validity of scores on each scale in PSTBAM by discussing each construct area with colleagues in order to make each item as clear and understandable as possible. Some items were adapted based on how words were spelled (color versus colour), clarification (my math teacher versus my teacher), and rewording of items (instead of “My math teachers have made me feel I have the ability to go on in mathematics”, it was agreed to change it to “My math teachers made me feel I have the ability to go on in mathematics; instead of “I was usually at ease in math classes,” it was modified to “I usually felt comfortable in math classes”; and instead of “I get a sinking feeling when I think of trying a math problem”, it was agreed to change it to “I get worried when I think of solving math problems.”

Reliability. Nunnally (1978) defined reliability as "the extent to which measurements are repeatable and that any random influence which tends to make measurements different from occasion to occasion is a source of measurement error" (p. 206). Reliability is most commonly measured using Cronbach's alpha, also known as coefficient alpha; this measure can be used to assess the internal consistency of a survey or questionnaire consisting of Likert-type scales. In social science research, the accepted cut-off occurs when alpha equals 0.70 or higher, indicating items are internally consistent. Bloom and Fischer (1982) stated,

> Fortunately, there is fairly general agreement as to what constitutes high reliability. If the figure you see on a measure indicates a correlation of 0.80 or better, …you can safely assume the instrument…is producing high, or good, reliability. Some researchers suggest that correlations of 0.70…are satisfactory. We would not dispute this. …it is simply the higher the reliability the better, and the standard of 0.80 should be a clear and useful guideline for you to use in selecting instruments. (p. 39)

A Cronbach’s alpha score can be influenced by the number of items in the scale and the sample of the study. If there is a small number of items in the scale, the Cronbach’s alpha value can be small. Up to a certain point, coefficients alpha of internal consistency increase when the number of items increases. Also, Cronbach's alpha can vary from one sample to another sample. Bademci (2004) emphasized reliability could be greatly affected by characteristics of the sample. Improving the reliability could be achieved by making testing or instrument instructions easily understood, writing items of the scale clearly, and making the procedures for scoring as explicit as possible (Nunnally, 1978). For the current study, the reliability was estimated by using Cronbach's alpha prior to combining items into scores for the variables. First, the researcher estimated the Cronbach's alpha for each of the six factors/scales. Then since there were two main constructs in the current instrument (belief in learning and teaching math, and attitude toward math), Cronbach's alpha was estimated for each construct independently.

Pilot Study

To determine the reliability of scores in the PSTBAM, a pilot study was conducted during spring 2016 with a convenience sample of 39 pre-service teachers majoring in elementary and special education at the junior level (Alazemi, 2016). The participants were native English speakers enrolled in an undergraduate teacher preparation program. The survey was administered to students during their math methods course and consisted of demographic information as well as items related to beliefs and attitude toward mathematics.

The participants in the pilot study were informed they were free to ask the researcher some questions if they did not understand any items of the survey. Once the participants completed the survey, the researcher asked them if there were items they did not understand and/or if items needed more clarification. Items that required the most clarification were found in the teacher subscale that measured student perceptions about how their math teachers felt about them as learners. Based on participant feedback, professional consultation, and findings from the research literature, the following changes were made to the survey instrument:

1. Demographic questions were changed to include the ACT score as well as the SAT score, information about academic major (special education, general education, elementary education, secondary education, mathematics, other), year in school (freshman, sophomore, junior, senior), major track (math, education new literacies, science, special education), and whether the participant planned on teaching math (yes, no).
2. Participants requested clarification about which grade level they were asked to recall regarding their school experiences to answer items in the Teacher Perception subscale.
3. Some participants mentioned that questions related to the student learning and teaching math subscales were unclear or so similar they had the same meaning. For the current study, no changes were made to the original items of each subscale; however, verbal clarification was provided to participants regarding these items during the instructions prior to administering the survey.
4. The original Likert scale included the responses *strongly disagree, disagree, undecided, agree, strongly agree*. Most of the participants chose the response *undecided* when they were not sure of the answer. After consulting with a professor in the Department of Applied Statistics and Research

Methods, the researcher decided to change the term *undecided* to the term *neutral* to elicit more accurate responses.

The researcher performed a reliability analysis to examine the internal consistency of the scores on the current research instrument. The reliability analysis was performed using all six factors: learning, teaching, anxiety-confidence, teacher perception, motivation, and usefulness. The Cronbach alpha was .638 for total scores on this instrument. This suggested a modest reliability for the total set of items. This reliability estimate could be interpreted based on several factors such as the length of the items, group heterogeneity, and the nature of the variables being measured. In the pilot study, the survey was distributed to only two junior-level classes. Additionally, the survey was administered at the end of the semester after students had taken a math methods course that included many constructivist activities. The survey combined two main concepts: attitudes toward math and beliefs in learning and teaching math (see Appendix A). The reliability assumption assumed unidimensionlity or homogeneity that measures a single construct. Therefore, it might be better to assess the reliability for each construct independently rather than combined in a total set.

Data Collection Procedures

Upon the approval from the Institutional Review Board (see Appendix B), the researcher met with the directors of the Schools of Education, Special Education, and Mathematical Science at the university where the study was conducted to explain the objectives of the study. She sought recommendations about which courses could be used to recruit participants based on their academic levels (freshman, sophomore, junior, senior) from the directors of each of these departments. Based on their suggestions, the researcher contacted the instructors of the classes via email and asked for permission to administer the survey to students in their classes. The time and location for administering the survey was addressed with each instructor. The survey instrument was then distributed to participants in the selected classrooms early in the semester before midterms during the fall semester of 2017.

Once instructors provided permission to conduct the survey in their class, the researcher introduced the research study to the pre-service teacher candidates. The purpose of the study and survey procedures were explained and the researcher handed out a copy of the PSTBAM along with a written informed consent form (see Appendix C). The informed consent form was read aloud to each class to ensure all potential participants understood the risks and benefits of the study as well as their right to participate, not participate, or withdraw at any time during the study. Participants were informed their responses were confidential, their responses would not be shared with their class instructor, and it would not affect their class grade.

Participants were also asked to read the informed consent information before starting the survey. By completing the survey, participants indicated their consent to participate in the study. Participants were provided 15-20 minutes to complete the survey. Each participant answered the survey individually and was not allowed to discuss the survey with other participants. However, participants were allowed to ask the researcher for clarification if needed to complete the survey. Finally, for each class that participated in the survey, a prize consisting of a $25 gift card to local businesses (i.e., Starbucks, Target, Panera) was offered to those participants who entered their name into a drawing.

Data Handling

The completed paper surveys will be stored in locked file cabinets in the researcher's office for no longer than three years. All electronic files related to the study including Excel files, SPSS analyses, field notes, and emails pertaining to the study will be kept on a password-protected computer. The data were used only for the research purpose of this study and will be destroyed once the study is completed.

Confidentiality

In survey research, confidentiality is an important aspect for respondents in order to ensure higher participation rates. Although confidentiality could not be guaranteed, the researcher undertook the following measures to ensure maximum confidentiality for the participants. Participants were not asked to include their names, thereby making it impossible to link participants' names or identities with their responses. No personal identifying information was gathered from participants. However, participants could have been identified based on their demographic information. Thus, it was important to know there was a potential to track and identify individual participants based on how their demographic information was reported. If a participant had a specific combination of demographic characteristics, i.e., the participant was a Hispanic male pre-service elementary teacher with a math minor, these characteristics could be used to identify this particular participant. To address this concern regarding participant confidentiality, demographic information was presented in aggregate form. The researcher handled these data by removing any recognizable characteristics and identities before disseminating the information. Throughout the study, the researcher was committed to maintaining the confidentiality of all participants so their responses were not shared with anyone. Finally, only aggregate data were shared with my research advisors.

Data Analysis Procedures

Prior to analysis, the researcher used Excel 2013 to manage the data. Once the data were entered into the Excel program, the Excel file was imported into SPSS. For the data analysis procedure, IBM SPSS 24 (Statistical Package for the Social Sciences--Student Version) was employed to analyze the data. Using SPSS, the researcher performed descriptive and inferential statistics. For the descriptive statistics, means, percent, variance, and standard deviations were reported. Reliability estimations were conducted before combining items into scores for each variable. For inferential statistics, MANOVA, multiple linear regression, and chi-square were performed to answer the research questions.

Variables and Factors

To compare pre-service teachers' beliefs and attitudes toward mathematics and learning and teaching mathematics, the independent variables were (a) academic majors (elementary education, special education, and secondary math education) and (b) academic level (freshmen, sophomore, junior, senior). The dependent variables included factors such as mathematics-rated affect (math anxiety and confidence), effectance motivation, usefulness of math, teacher perception, teaching mathematics and learning mathematics. In addition to finding the relationship between pre-service teachers' attitudes about math as defined by mathematics-rated affect (math anxiety-confidence), effectance motivation, usefulness, teacher perception and their beliefs in learning and teaching math, the independent variables were determined by factors such as math anxiety-confidence (mathematics-rated affect), effectance motivation, usefulness, and teacher perception. Whereas the dependent variables were the participants' beliefs in student learning and teaching mathematics.

Scoring the Data

Participants' beliefs and attitude toward mathematics were measured using the variables of confidence, math anxiety, usefulness of math, effectance motivation, teacher perception, student learning, and teaching math. A 5-point-Likert scale (i.e., 1=*Strongly Disagree*, 2=*Disagree*, 3=*Neutral*, 4=*Agree*, and 5=*Strongly Agree*) was utilized to obtain participants' responses. If a participant *strongly agreed* with a positive item, this score would indicate the participant's beliefs and attitude level in that item was the highest and vice versa if the participant chose the response *strongly disagree*. For example, the Confidence factor measured the participant's ability to approach and complete mathematics tasks. If the participant chose *strongly agree* for "I am sure I can do advanced work in mathematics," that would indicate the highest level of confidence in mathematical ability. The Math Anxiety factor measures the level of math anxiety and its impact on participants' performance in mathematics. One example of math anxiety was "Mathematics usually makes me feel uncomfortable and nervous." If the pre-service teacher responded by choosing *strongly agree*, that would indicate the participant had a high level of math anxiety. However, if the pre-service teacher responded by selecting *strongly disagree*, that would indicate the lowest level of math anxiety.

Pre-service teachers' approach to math fell into one of two categories--the traditional or the constructivist approach--and was expressed by their beliefs in learning and teaching math. An example of a traditional approach was "Children should not solve simple word problems until they have mastered some number facts." If the participant chose *strongly agree* for this item, that would indicate traditional beliefs were held by the participant toward how children learn mathematics. To discriminate between the traditional and constructivist approaches, items related to the traditional approach were negatively weighted while items related to the constructivist approach were positively weighted. Thus, a low score on this scale indicated the participants believed children received and obtained their math knowledge directly from their teachers. On the other hand, a high score indicated participants believed children could learn mathematics through constructing their own knowledge.

An example of a constructivist approach was "The goals of instruction in mathematics are best achieved when students find their own methods for solving problems." Participants who *strongly agreed* with this item would indicate they held constructivist beliefs in teaching mathematics. A high score on this sub-scale indicated teachers have a role as facilitator, while a low score implied teachers have a role in directing students' learning.

Participants' responses were converted to numbers and scored from 1-5 on each item. Positive items were given 5 points if the participant response was *strongly agree*. Negative items were given 1 point if the participant's response was *strongly agree* (after recoding). The cumulative total of participants' scores in scales indicated the participants' beliefs and attitudes in mathematics; a higher score meant more positive beliefs and attitudes were held by the participants.

Statistical Methods

The distribution of the measured variables of effectance motivation, usefulness of math, teacher perception, math rated affect, student learning and teaching math was based on the Likert scale and normality of the distributions of these variables was determined in order to use the appropriate parametric or nonparametric method of inferential analysis. Various statistical methods determined significance of dependent variables (DV) in relation to levels of independent variables (IV). Analysis of variance tested the significance of DV mean differences for each individual DV. Multivariate analysis of variance tested DV mean differences for more than one DV at the same time. However, MANOVA had a number of advantages over ANOVA. Testing several DVs instead of only one improved the chance of discovering what was significant at different levels of an IV. Also, using MANOVA over a series of ANOVA tests protected against inflated Type I errors due to correlated DVs (Huberty & Morris, 1989; Tabachnik & Fidell, 2007).

To answer the research questions, the researcher conducted the following analyses:

> Q1 Are there differences among pre-service teachers' academic levels (freshmen, sophomore, junior, and senior) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect (math anxiety and confidence), teacher perception, student learning, and teaching math)?"

A MANOVA was used to determine if there was a statistically significant difference among pre-service teachers' beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect, teacher perception, student learning, and teaching math) on their academic year levels (freshmen, sophomore, junior, and senior). The MANOVA is a fairly robust test because the results are still trustworthy even in the presence of non-normal data. Before carrying out a MANOVA, the researcher checked for the following assumptions:

1. The data from group i has common mean vector μi
2. The data from all groups have common variance-covariance matrix Σ.
3. Independence: The subjects are independently sampled.
4. Normality: The data are multivariate normally distributed. For large samples, the central limit theorem says the sample mean vectors are approximately multivariate normally distributed, even if the individual observations were not. The testing of difference among the means was tested at an alpha $\alpha=0.05$, the MANOVA test of significance.

Q2 Are there differences among pre-service teachers' major (elementary, special education, and secondary math) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect (math anxiety and confidence), teacher perception, student learning, and teaching math)?

Similar to the first research question, the researcher used MANOVA to determine if there was a statistically significant difference on pre-service teachers' beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect, teacher perception, student learning, and teaching math) among pre-service teachers' major (elementary, special education, and secondary math).

Q3 Are there differences in pre-service teachers' plans to teach math (Yes, No) and their desirability to teach math (Desirable, Undesirable) across their major (special, elementary, secondary math)?

Chi-square analysis was used to determine if there was a statistically significant difference among pre-service teachers' academic major (special, elementary, secondary math) based on their plans to teach math (Yes, No) and their desirability to teach math.

The two variables under study were shown on a two-way table (also called a contingency table), which is a useful tool for examining relationships between categorical variables. The entries in the cells of a two-way table could be frequency counts or relative frequencies (just like a one-way table). The idea was based on cross-tabulation of the data--a joint frequency distribution of cases based on two or more categorical variables. Displaying a distribution of cases by their values on two or more variables is known as a contingency table analysis and is one of the more commonly used analytic methods in the social sciences.

The chi-square test of independence was used to determine if there was a significant relationship between two nominal (categorical) variables. The frequency of one nominal variable was compared with different values of the second nominal variable. A chi-square test was used to determine whether there was a significant difference between the expected frequencies and the observed frequencies in one or more categories. The chi-square test can be used to attempt rejection of the null hypothesis when the data are independent.

Q4 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness of math, math rated affect, teacher perception) relate to their beliefs in student learning in mathematics?

A correlation analysis was done among all measured variables and independent variables. To determine whether "learning mathematics" could be explained using the other measured variables, a multiple linear regression was performed--a statistical procedure for investigating and modeling the relationships between one dependent variable and more than one independent variable (Montgomery, Peck, & Vining, 2006). Specifically, the researcher generated multiple regression models based on stepwise, backward, and forward selection methods. Multicollinearity was checked among independent variables and significance testing of variable coefficients was performed (Montgomery et al., 2006). The following multiple linear regression assumptions were closely monitored:

1. Linearity and additivity: To assess whether the linearity assumption is tenable, it is customary to plot the residuals versus each of the independent variables.
2. Independence: Assessing the validity of the statistical independence of the observations depends mainly on understanding of how the data were collected. When sampling is not actually random, as in convenience sampling, one must assess firstly whether the sampling process is likely to have been susceptible to bias.
3. Equal variance or homogeneous dispersion: To test for equal variance use plots of standardized errors vs. fitted values. The scatter pattern should not exhibit increasing or decreasing variance but rather uniform distribution of errors.
4. Normality: The assumption of normality is the least critical assumption for most purposes in the sense that with large samples, the central limit theorem will provide enough normality to allow the application of tests and confidence intervals.

Through regression modeling, the researcher investigated the relationship between variables (correlations), estimated the coefficient of each significant variable, ran diagnostics to test the significance of the estimated coefficients, and created a predictive model for future observations.

> Q5 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness, math rated anxiety, teacher perception) relate to their beliefs in teaching mathematics?

Similar to the fourth research question, a correlation analysis was performed among all measured variables and independent variables. To determine whether "teaching mathematics" could be explained using the other measured variables, a multiple linear regression was utilized.

Conclusion

The goal of this study was to determine whether there was a difference in the beliefs and attitudes toward math between pre-service special and general education teachers and if there were differences and how the differences were related to their beliefs in learning and teaching mathematics. A non-probability convenience sample was recruited among students enrolled in teacher preparation programs at a Rocky Mountain regional university. Using a 51-item survey (the PSTBAM), which was adapted from three existing surveys, pre-service teachers' beliefs and attitudes toward math were examined and compared with their academic major and level. Responses were analyzed using MANOVA, multiple linear regression, and chi-square to answer this study's research questions.

CHAPTER IV

RESULTS

Introduction

In this chapter, results of pre-service teachers' responses on measures of beliefs and attitudes toward mathematics, learning, and teaching mathematics as obtained by the Pre-Service Teachers Beliefs and Attitudes toward Mathematics (PSTBAM) survey are presented. Inferential and descriptive statistics are presented in more detail to answer the five research questions and to describe the sample of this study.

The purpose of this research study was to examine and compare the beliefs and attitudes of pre-service special, elementary, and secondary math education teacher candidates regarding mathematics and the learning and teaching of mathematics. A quantitative survey was administered to undergraduate education majors to examine their beliefs and attitudes about math and explore factors including math anxiety, confidence, motivation, value and usefulness of math, and the effect of previous teachers' perceptions. The interrelationship among these factors was explored and compared to participants' academic levels (freshmen, sophomore, junior, and senior) and academic majors (special education, elementary education, and secondary math education) to determine whether these factors influenced the approaches pre-service teachers thought and believed they would use when teaching math.

Using SPSS 24, descriptive statistics including mean, percent, variance, and standard deviation were calculated. Inferential statistics including MANOVA, multiple linear regression, and chi-square were also performed to answer the research questions.

Multivariate analysis of variance was used to determine if there was a statistically significant difference among pre-service teachers' beliefs and attitudes in mathematics (i.e., effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perceptions, student learning, and teaching math) based on their academic levels (i.e., freshmen, sophomore, junior, and senior). Multivariate analysis of variance was also used to determine if there was a statistically significant difference on pre-service teachers' beliefs and attitudes in mathematics (i.e., effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher' perception, student learning, and teaching math) among pre-service teachers' major (i.e., elementary, special education, and secondary math).

Chi-square analysis was used to determine if there was a statistically significant difference among pre-service teachers' academic major (special, elementary, secondary math) based on their plans to teach math (Yes, No) and their desire to teach math.

Multiple linear regression analysis was used to determine what statistically significant relationships existed between pre-service teachers' attitudes towards math (i.e., effectance motivation, usefulness, math related anxiety, and teacher perception) and their beliefs in teaching math. Multiple linear regression analysis was also used to determine what statistically significant relationships existed between pre-service teachers' attitudes towards math (i.e., effectance motivation, usefulness of math, math related anxiety, and teacher perception) and beliefs of student learning in mathematics.

In the following section, more details are presented about the characteristics of the sample of this study. Also, the reliability of each subscale and the two instruments--beliefs in learning and teaching math, and the attitude toward mathematics--is described. In addition, results are presented related to all five research questions.

Descriptive Statistics

Attitudes toward mathematics, beliefs in teaching and learning mathematics, planning to teach math, desirability in teaching math, and demographic information such as academic majors, academic levels, age, gender, ethnicity, the highest level of high school math, GPA, and AST or ACT math score were collected to provide a descriptive analysis of the sample.

All participants were recruited from two colleges: Education and Behavioral Sciences and Natural and Health of Science at one public university. During 2016, undergraduate student enrollment in special education, elementary education, and secondary math education programs were 198, 532, and 121, respectively. For this study, 362 respondents completed the survey. Of those who participated, 58% (n = 210) were general education, 33.4% (n = 121) were special education, and 8.6% (n = 31) were secondary math education

The majority of participants, across all the three programs, were from the junior and senior levels. Table 1 presents the percentages of each academic level within each academic major/program.

Table 1

Percentages at Each Academic Level for the Three Academic Majors

Years in school	Special Education	Elementary Education	Secondary Math Education
Freshmen	2.5%	14.8%	25.8%
Sophomore	24.8%	15.2%	6.5%
Junior	34.7%	34.8%	35.5%
Senior	38.0%	35.2%	32.3%

The majority of participants were female in special education (93.3%), elementary education (95.7%), and secondary math education (61.3%). The age of the sample ranged from 18 to 50 years. The majority of participants were in the category 18-22 years old: special education was 86.0%, elementary education was 90.0%, and secondary math education was 87.1% (see Table 2).

Table 2

Percentages of Participants' Age for the Three Majors

Academic major	Age						
	18-22	23-25	26-30	31-35	36-40	41-50	51+
Special Education	86.0%	8.3%	3.3%	1.7%	0.0%	0.8%	0.0%
Elementary Education	90.0%	5.3%	2.4%	1.0%	0.5%	1.0%	0.0%
Secondary Math Education	87.1%	3.2%	6.5%	0.0%	3.2%	0.0%	0.0%

The majority of participants were Caucasian in special education (76.7%), elementary education (80.3%), and secondary math education (78.0%). Table 3 presents further information on the ethnic breakdown of the sample.

Table 3

Percentages of Participant Ethnicity for the Three Majors

Academic Major	Ethnicity							
	American Indian	Asian or Pacific Islander	Caucasian	Hispanic	African American	Middle Eastern	Other	Prefer not to answer
Special Education	0.0 %	1.7%	76.7%	13.3%	3.3%	0.0%	3.3%	1.7%
Elementary Education	1.0%	1.4%	80.3%	13.0%	0.5%	1.0%	1.4%	1.4%
Secondary Math Education	0.6%	2.2%	78.0%	13.6%	1.4%	0.6%	1.9%	1.7%

Overall high school GPA was categorized in five groups: (a) less than 2, (b) 2.0-2.5, (c) 2.6-3.0, (d) 3.1-3.5, and (e) 3.6-4.0. The average GPA group for all participants was 3.1-3.5 (*M* = 4.31; *SD* = .817). Also, the high school average GPA in mathematics was divided into five groups: (a) less than 2, (b) 2.0-2.5, (c) 2.6-3.0, (d) 3.1-3.5, and (e) 3.6-4.0. The high school average GPA group in mathematics for all participants was 3.1-3.5 (*M* = 3.95, *SD* = .954). Participants were asked to provide their scores on the SAT and/or ACT; however, only 2.2 % of the participants reported their SAT scores (*M* = 570; *SD* =147.65) while 57.5% of the participants reported their ACT scores (*M* =23.44; SD = 4.83). Table 4 presents the GPA percentages and the high school average scores in mathematics based on the academic majors. Table 5 presents the means and standard deviations of SAT and ACT scores based on the three academic majors.

Table 4

Percentages of Participants' High School Average Scores in Math and Overall High School Grade Point Average for the Three Majors

Academic Major	High School Average Scores in Math					Overall High School GPA				
	<2.0	2.0-2.5	2.6-3.0	3.1-3.5	3.6-4.0	<2.0	2.0-2.5	2.6-3.0	3.1-3.5	3.6-4.0
Special Education	0.8%	7.5%	31.7%	40.0%	19.2%	0.8%	0.8%	18.2%	41.3%	38.8%
Elementary Education	0.5%	7.3%	20.4%	33.0%	38.8%	0%	3.4%	10.1%	33.3%	53.1%
Secondary Math Education	0.6%	7.0%	23.4%	34.6%	34.4%	0%	3.3%	3.3%	26.7%	66.7%

Table 5

Means and Standard Deviations on High School Achievement Scores for the Three Academic Majors

Major		Score on the Math Section of the SAT?	Score on the Math Section of the ACT?
Special Education	*M*	575.00	22.70
	n	4	60
	SD	206.155	4.637
Elementary Education	*M*	553.33	23.23
	n	3	128
	SD	107.858	4.825
Secondary Math Education	*M*	600.00	26.95
	n	1	20
	SD	NA	4.123
Total	*M*	570.00	23.44
	n	8	208
	SD	147.648	4.832

The participants were asked to indicate their highest level of high school mathematics. This question was divided into seven options: (a) algebra 1, (b) algebra 2, (c) geometry, (d) trigonometry, (e) pre-calculus, (f) calculus, and (g) other. Table 6 presents more detail on the highest level of high school math based on academic majors.

Table 6

Highest Level of High School Math for the Three Majors

Major	Highest Level of High School Math						
	Algebra 1	Algebra 2	Geometry	Trigonometry	Pre-calculus	Calculus	Others
Special Education	2.5%	10.7%	16.5%	18.2%	23.1%	14.0%	14.9%
Elementary Education	0.0%	10.5%	10.0%	16.7%	33.5%	17.2%	12.0%
Secondary Math Education	3.2%	3.2%	0.0%	6.5%	16.1%	61.3%	9.7%

In addition, participants were asked to describe and rate their math ability and knowledge by choosing one option from the following: (a) very poor, (b) poor, (c) acceptable, (d) good, and (e) very good. The mean for all participants on average group was 3.57 and the standard deviation was .854. Findings indicated participants described their math ability on average as acceptable to good. The following means and standard divisions were based on each major: special education (*M* = 3.34, *SD* =. 936), elementary education (*M* = 3.63, *SD* =. 792), and secondary math education (*M* =4.00, *SD*= .683). Table 7 presents the percentages of the participants' responses on how they described their math ability and knowledge.

Table 7

Participant Responses Describing Math Ability and Knowledge Across Academic Majors

Major	Description of Math Ability and Knowledge?				
	Very Poor	Poor	Acceptable	Good	Very Good
Special Education	3.3%	12.4%	41.3%	33.1%	9.9%
Elementary Education	1.0%	4.8%	36.4%	45.9%	12.0%
Secondary Math Education	0.0%	0.0%	22.6%	54.8%	22.6%

A question about how many math courses participants had taken in their program was asked in the survey. In Table 8, the percentages of the number of math courses the participants took in their program are presented according to academic major.

Table 8

Participant Responses Regarding Number of Math Courses Taken in Program

Major	Number of Math Courses Taken in Program														
	0	1	2	3	4	5	6	7	8	10	11	12	13	15	16
Special Education	1.0	14	18	42	21	3	0	1	0	0	0	0	0	0	0
Elementary Education	1.2	9.5	10.7	53.6	18.5	2.4	0.6	3	0.6	0	0	0	0	0	0
Secondary Math Education	0	8.3	16.7	4.2	8.3	4.2	0	4.2	4.2	16.7	4.2	4.2	12.5	8.3	4.2

All numbers are expressed in percentages.

A question was asked about whether participants agreed or disagreed that math is a male domain. Five answer options were given: (a) *strongly disagree*, (b) *disagree*, (c) *neutral*, (d) *agree*, and (e) *strongly agree*. On average, participants disagreed that math is a male domain (*M* = 2.04, *SD* = 1.02). Table 9 presents a breakdown of this question according to academic focus.

Table 9

Participant Responses Regarding Math as a Male Domain

Academic major	Math Is a Male Domain						
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	*M*	*SD*
Special Education	36.7%	40.0%	11.7%	8.3%	2.5%	1.99	1.025
Elementary Education	34.4%	42.1%	12.9%	9.1%	1.4%	2.01	.985
Secondary Math Education	22.6%	32.3%	22.6%	19.4%	3.2%	2.48	1.151

Participants were asked to indicate whether they received support in math from their parent/s or not. This question was categorized into four groups: (a) mother, (b) father, (c) both, and (d) neither. Table 10 presents the percentage of participants' responses in each academic program.

Table 10

Participant Responses Regarding Support Received in Math

Academic major	From Whom Support Received in Math			
	Mother	Father	Both	Neither
Special Education	8.3%	16.7%	38.3%	36.7%
Elementary Education	13.4%	15.3%	50.7%	20.6%
Secondary Math Education	9.7%	9.7%	51.6%	29.0%

Participants were asked to indicate whether or not they had negative school experiences in math classes. If they answered yes, they were asked about the school level when they had negative experiences by choosing one option from the following: (a) elementary school, (b) middle school, (c) high school, (d) college, and (e) two or more levels/schools. Findings revealed 46.4% of participants (all majors in one group) had negative school experiences in math classes whereas 53.0% did not have negative school experiences in math classes. Of those who had negative school experiences in math classes, 41.1% had negative school experience in high school. Tables 11 and 12 provide more details in percentages of the participants' responses in each academic major/program.

Table 11

Participant Responses on Negative School Experiences in Math Classes According to Each Academic Major/Program

Academic Major	Negative School Experiences in Math Classes	
	No	Yes
Special Education	45.0%	55.0%
Elementary Education	53.6%	46.4%
Secondary Math Education	83.9%	16.1%

Table 12

Participant Responses on School Level When Negative School Experience Was Given According to Each Academic Major/Program

Academic major	School Level When Negative School Experience Given				
	Elementary school	Middle school	High school	College	Two or more levels
Special Education	6.1%	16.7%	25.8%	1.5%	50.0%
Elementary Education	8.2%	15.5%	50.5%	1.0%	24.7%
Secondary Math Education	0.0%	0.0%	60.0%	0.0%	40.0%

Note: These percentages for participants who said yes to negative school experiences.

Participants were asked to answer how their math teachers taught math at the secondary school level. The participants had the chance to choose one option from the following: (a) using a variety of ways and strategies (i.e., manipulatives, visual aids, cooperative learning); (b) emphasizing an understanding of the actual meaning behind math concepts; (c) focusing on following rules and memorizing facts; (d) all of the previous options; (e) options A and B; (f) options A and C; and (g) options B and C. Table 13 presents the percentages for each academic program.

Table 13

Ways Math Teachers at Secondary School Levels Taught Math for Each Academic Major/Program

Academic major	Ways Math Teachers at Secondary School Levels Taught Math						
	A-Using variety of ways and strategies (i.e., manipulatives, visual aids, cooperative learning)	B-Emphasizing an understanding of the actual meaning behind math concepts	C-Focusing on following rules and memorizing facts	All the pervious options	Option A and B	Option A and C	Option B and C
Special Education	5.9%	0.0%	16.8%	31.9%	17.6%	15.1%	12.6%
Elementary Education	3.4%	0.5%	16.8%	45.7%	9.6%	15.9%	8.2%
Secondary Math Education	0.0%	6.5%	12.9%	41.9%	29.0%	9.7%	0.0%

Tables 14 and 15 show the descriptive statistics for all six factors (student learning, teaching math, math rated affect, effectance motivation, teacher perception, usefulness of math) by majors as well as overall means and standard deviations. In general, the means for secondary math education respondents were higher than both the elementary and special education majors for all six factors. Also, the means for elementary education respondents were higher than special education majors for all six factors. The strongest factor on average for all respondents was usefulness (M= 4.19, SD

= 0.61), showing close to *strongly agree* on the 5-point Likert scale, followed by teacher perception (*M* = 3.78, *SD* = 0.70).

Table 14

Mean Scores for Participants on Scales Measuring Beliefs in Student Learning and Teaching Math

Academic major		Students Learning	Teaching Math	Total
Special Education	*M*	2.67	3.56	3.12
	N	121	121	121
	SD	0.55	0.56	0.55
Elementary Education	*M*	2.72	3.39	3.05
	N	210	210	210
	SD	0.58	0.50	0.54
Secondary Math Education	*M*	2.83	3.88	3.35
	N	31	31	31
	SD	0.58	0.46	0.52
Total	*M*	2.71	3.49	
	N	362	362	
	SD	0.57	0.54	

Table 15

Means and Standard Deviations of Participants on Scales Measuring Math Related Affect, Effectance Motivation, Usefulness of Math, and Total Teacher Perception of Attitudes Toward Math

Academic major		Math Rated Affect	Effectance Motivation	Teacher Perception	Usefulness of Math	Total
Special Education	*M*	3.01	3.10	3.63	3.88	3.41
	N	121	121	121	121	121
	SD	1.12	0.79	0.77	0.73	0.85
Elementary Education	*M*	3.32	3.24	3.81	4.28	3.66
	N	210	210	210	210	210
	SD	1.06	0.81	0.64	0.47	0.74
Secondary Math Education	*M*	3.89	4.16	4.13	4.76	4.243
	N	31	31	31	31	31
	SD	0.64	0.48	0.65	0.27	0.51
Total	*M*	3.26	3.27	3.78	4.19	
	N	362	362	362	362	
	SD	1.07	0.83	0.70	0.61	

Table 16 presents the descriptive statistic including means and standard deviations of confidence and math anxiety as both are combined into one scale (math rated affect).

Table 16

Means and Standard Deviations of Participants on Scales Measuring Math Anxiety and Confidence

Academic Major		Confidence	Math Anxiety
Special Education	*M*	3.03	2.99
	N	121	121
	SD	1.15	1.14
Elementary Education	*M*	3.38	3.28
	N	210	210
	SD	1.12	1.06
Secondary Math Education	*M*	3.86	3.92
	N	31	31
	SD	0.72	0.70
Total	*M*	3.30	3.23
	N	362	362
	SD	1.13	1.09

Reliability

The researcher performed a reliability test to examine the internal consistency of the current research instrument using Cronbach's alpha. Reliability analysis was performed in two steps. First, reliability analysis was performed for each factor separately: student learning, teaching math, math rated affect, effectance motivation, usefulness in math, and teacher perception. Second, reliability analysis was performed for each construct: (a) belief construct combining student learning and teaching math, and (b) attitudes construct combining math rated affect, effectance motivation, usefulness in math, and teacher perception. Table 17 presents Cronbach's alpha for each scale.

Table 17

Cronbach's Alpha for Instrument Scales

Scale	Reliability (Cronbach's alpha)
Beliefs in Learning and Teaching Math	0.64
Student Learning	0.57
Teaching Math	0.66
Attitudes Toward Math	0.96
Math Rated Affect	0.96
Effectance Motivation	0.95
Usefulness in Math	0.93
Teacher Perception	0.87

The reliability scores for the attitude constructs (math rated affect, effectance motivation, usefulness in math, and teacher perception) were high. It was notable that the belief constructs (student learning and teaching math) had low reliability scores; however, the researcher continued the data analysis with caution.

Inferential Statistics

Q1 Are there differences among pre-service teachers' academic levels (freshmen, sophomore, junior, and senior) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

The researcher was planning to examine the differences among pre-service teachers' academic levels in each academic major with regard to their beliefs and attitudes in mathematics. However, due to an insufficient number of respondents from the secondary math education program (n = 31) as well as freshmen special education (n = 3), it was challenging to find differences in their beliefs and attitudes toward math across their academic levels (freshmen, sophomore, junior, and senior) with regard to secondary math education and special education. Thus, finding and analyzing differences among pre-service teachers' academic year levels was performed by combining all the respondents in one group with no emphasis on majors.

A MANOVA test with $\alpha = 0.05$ and Pillai's Trace as the test statistic were performed to determine if there were significant differences among pre-services teachers' academic year levels in relation to their beliefs and attitudes in mathematics (Olson, 1974). Six factors of beliefs and attitudes toward mathematics were assessed: student learning, teaching math, math rated affect (math anxiety and confidence), effectance motivation, usefulness of math, and teacher perception. Pre-service teachers were from four academic levels: freshmen, sophomore, junior, and senior. The differences among pre-services teachers' academic year levels in relation to their beliefs and attitudes in mathematics were not statistically significant, $F(18, 1065) = .919$, $p > .05$, partial $\eta^2 = 0.015$ (see Table 18).

Table 18

Multivariate Analysis of Overall Beliefs and Attitude Toward Math Across Academic Years

Effect		Value	*F*	Hypothesis df	Error df	Sig.	Partial η^2
Year	Pillai's Trace	.046	.919	18.000	1065.000	.555	.015
	Wilks' Lambda	.955	.921	18.000	998.920	.553	.015
	Hotelling's Trace	.047	.922	18.000	1055.000	.551	.015
	Roy's Largest Root	.035	2.076[c]	6.000	355.000	.055	.034

Pre-service teachers in freshmen, sophomore, junior, and senior years scored higher in the usefulness of math scale (*M* = 4.13, *SD* = 0.51; *M* = 4.09, *SD* =0 .65; *M* = 4.18, *SD* = 0.66 and *M* = 4.27, *SD* =0 .59, respectively) than on the other scales. Pre-service teachers in the freshmen, sophomore, junior, and senior years scored lower on the student learning scale (*M* = 2.69, *SD* = 0.44; *M* = 2.65, *SD* = 0.55; *M* = 2.73, *SD* = 0.55 and *M* = 2.73, *SD* = 0.63, respectively; see Appendix D for more descriptive statistics).

Q2 Are there differences among pre-service teachers' major (elementary, special education, and secondary math) in relation to their beliefs and attitudes in mathematics (effectance motivation, usefulness of math, math rated affect [math anxiety and confidence], teacher perception, student learning, and teaching math)?

A MANOVA test with $\alpha = 0.05$ and Pillai's Trace were used to determine if there were significant differences among type of pre-services teachers' in relation to their beliefs and attitudes in mathematics (Olson, 1974). Six factors of beliefs and attitudes toward mathematics were assessed: student learning, teaching math, math rated affect (math anxiety and confidence), effectance motivation, usefulness of math, and teacher perception. Pre-service teachers in special, elementary, and secondary math education scored higher on the Usefulness of Math scale (*M* = 3.88, *SD* = 0.73; *M* = 4.28, *SD* = 0.48 and *M* = 4.76, *SD* = 0.28 respectively) than on the other scales. Pre-service teachers in special, elementary, and secondary math education scored lower on the student learning scale (*M* = 2.67, *SD* = 0.55; *M* = 2.72, *SD* = 0.58 and *M* = 2.83, *SD* =0 .58, respectively; see Appendix E for descriptive statistics).

The differences among the type of pre-services teachers' with regard to their beliefs and attitudes in mathematics on the combined dependent variables were statistically significant, $F(12,710) = 10.552$, $p < 0.001$, partial $\eta^2 = 0.151$. The MANOVA showed statistically significantly differences in beliefs and attitudes toward mathematics among the pre-service teachers' academic majors at $\alpha = 0.05$ (see Table 19).

Table 19

Multivariate Analysis of Overall Beliefs and Attitudes Toward Math Across Academic Major

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial η^2
Academic Major	Pillai's Trace	.303	10.552	12.000	710.000	.000	.151
	Wilks' Lambda	.719	10.572	12.000	708.000	.000	.152
	Hotelling's Trace	.360	10.591	12.000	706.000	.000	.153
	Roy's Largest Root	.225	13.289	6.000	355.000	.000	.183

Findings indicated all the variables showed statistically significant differences among pre-service teachers' majors except for student learning (see Table 20).

Table 20

Tests of Between Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial η^2
Academic Major	Student Learning	.609	2	.304	.928	.396	.005
	Teaching Math	7.403	2	3.702	13.433	.000	.070
	Math Rated Affect	20.923	2	10.461	9.405	.000	.050
	Effectance Motivation	28.664	2	14.332	23.326	.000	.115
	Teacher Perception	6.716	2	3.358	6.956	.001	.037
	Usefulness of Math	23.195	2	11.597	36.310	.000	.168

Multiple comparisons were applied using post-hoc tests such as Tukey, Scheffe, and least significant difference. All tests showed similar results (see Appendix F). For example, Tukey post-hoc tests (see Table 21) showed statistically significant differences for teaching math scores across all three majors. The highest mean difference was between secondary math education and elementary education (M = 0.48) followed by mean differences between secondary math education and special education teachers (M = 0.31). Pre-service special education teachers significantly differed in teaching math in comparison to pre-service elementary education teachers (p = 0.011). Also, pre-service secondary math education teachers significantly differed in teaching math in comparison to special education pre-service teachers (p = 0.009) and elementary education pre-service teachers (p = 0.011).

Table 21

Multiple Comparisons Using Tukey Post-Hoc Tests

Dependent Variable		Special Education (I)		Elementary Education (I)
		Elementary Education (J)	Secondary Math Education (J)	Secondary Math Education (J)
Teaching Math	Mean Difference (I-J)	0.1740*	- 0.3128*	- 0.4869*
	Std. Error	0.05991	0.10567	0.10100
	Sig.	0.011	0.009	0.000
Math Rated Affect	Mean Difference (I-J)	- 0.3120*	- 0.8868*	- 0.5748*
	Std. Error	0.12037	0.21230	0.20292
	Sig.	0.027	0.000	0.013
Effectance Motivation	Mean Difference (I-J)	- 0.1387	-1.0673*	- 0.9287*
	Std. Error	0.08946	0.15779	0.15082
	Sig.	0.269	0.000	0.000
Teacher Perception	Mean Difference (I-J)	- 0.1796	- 0.5007*	- 0.3211*
	Std. Error	0.07929	0.13986	0.13368
	Sig.	0.062	0.001	0.044
Usefulness of Math	Mean Difference (I-J)	- 0.3957*	- 0.8789*	- 0.4833*
	Std. Error	0.06450	0.11377	0.10874
	Sig.	0.000	0.000	0.000

For the math rated affect scale, Tukey post-hoc tests showed statistically significant differences across majors. The highest mean difference was between secondary math education and special education teachers (M = 0.88) followed by mean differences between secondary math education and elementary education teachers (M =0.57). Pre-service elementary education teachers had higher mean scores than pre-service special education teachers (p = .027). Also, pre-service teachers in secondary math education had higher mean scores than pre-service teachers in special education (p < 0.001) and elementary education pre-service teachers (p = 0.013).

Tukey post-hoc tests showed statistically significant differences for effectance motivation across majors. The highest mean difference was between secondary math education and special education teachers (M = 1.06) followed by the mean differences between secondary math education and elementary education teachers (M =0.92). Pre-service teachers in secondary math education had higher mean scores in effectance motivation than pre-service teachers in special and elementary education (p < 0.001 for both majors). However, the difference between elementary education and special education pre-service teachers on this scale was not significantly significant.

Tukey post-hoc tests showed statistically significant differences for teacher perception across majors. The highest mean difference was between secondary math education and special education teachers (M = 0.50) followed by the mean differences between secondary math education and elementary education teachers (M = 0.32). Pre-service teachers in secondary math education had higher mean scores than pre-service teachers in special education (p = 0.001) and elementary education (p = 0.044).

Also, Tukey post-hoc tests showed statistically significant differences for usefulness of math across majors. The highest mean difference was between secondary math education and special education teachers (M = 0.87) followed by mean differences between secondary math education and elementary education teachers (M = 0.48). Pre-service teachers from elementary education had higher mean scores than pre-service teachers from special education (p < 0.001). In addition, pre-service teachers in secondary math education had higher mean scores than pre-service teachers in special and elementary education (*p* < 0.001).

Q3 Are there differences in pre-service teachers' plans to teach math (Yes, No) and their desirability to teach math (Desirable, Undesirable) across their major (special, elementary, secondary math)?

Q3a. Are there differences in pre-service teachers' plans to teach math (Yes, No) across their major (special, elementary, secondary math)?

Three hundred and sixty-two pre-service teachers from three academic majors (special, elementary and secondary math education) were asked to report whether or not they were planning to teach math. Table 22 shows that based on all chi-square-type tests, the relationship between major and planning to teach math was statistically significant (at *p* <. 001). Descriptive statistics show 64.5% of special education pre-service teacher and 22.5% of elementary education pre-service teachers were not planning on teaching math. (see Table 23).

Table 22

Chi-Square Tests of Relationship Between Major and Plan to Teach Math

	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	77.609[a]	2	.000
Likelihood Ratio	85.491	2	.000
Linear-by-Linear Association	74.590	1	.000
N of Valid Cases	361		

Table 23

Plan to Teach Math--Academic Major Cross Tabulation

Are you planning to teach math	Special Education	Elementary Education	Secondary Math Education	Total
No	78 64.5%	47 22.5%	0 0.0%	125 34.6%
Yes	43 33.5%	162 77.5%	31 100%	236 65.4%
Total	121	209	31	361

Q3b Are there differences in pre-service teachers' desirability to teach math across their major (special, elementary, secondary math)?

Three hundred and sixty-two pre-service teachers from three academic majors--special, elementary and secondary math education--were asked to report whether or not they desired to teach math. Table 24 shows a statistically significant relationship between major and desire to teach math at $p <. 001$. Descriptive statistics show 60.3% of special education pre-service teachers and 39.2% of elementary education pre-service teachers did not desire to teach math (see Table 25).

Table 24

Chi-Square Tests of Relationship Between Major and Desire to Teach Math

	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	39.436[a]	2	.000
Likelihood Ratio	50.714	2	.000
Linear-by-Linear Association	37.083	1	.000
N of Valid Cases	361		

Table 25

Desire to Teach Math--Academic Major Cross Tabulation

How desirable to teach math	Special Education	Elementary Education	Secondary Math Education	Total
Not desirable	73 60.3%	82 39.2%	0 0.0%	155 42.9%
Desirable	48 39.7%	127 60.8%	31 100%	206 57.1%
Total	121	209	31	361

Q4 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness of math, math rated affect, teacher perception) relate to their beliefs in Student learning in mathematics?

For the fourth research question, a multiple linear regression analysis was performed. The dependent variable was student learning and the predictors were effectance motivation, usefulness of math, math rated affect, and teacher perception. All five predictors were initially included in the model. Multiple regression models based on stepwise, backward, and forward selection methods were generated and are presented in Appendix G. Using the backwards selection method; the final model included two predictors--math rated affect and teacher perception--that could explain student learning. The results showed the regression analysis was statistically significant and a significant relationship wasfound on pre-service teachers' beliefs in student learning and math rated affect (t =3.91, p = 0.001). Also, the relationship between pre-service teachers' beliefs in student learning and teacher perception approached significance (t = -1.96, p = 0.051). In addition, the adjusted R-squared (R^2_{adj} = 0.036), which indicated less than 4% of the variation in student learning, was explained by the model (i.e., by math rated affect and teacher perception; see Table 26).

Table 26

Multiple Linear Regression for the Dependent Variable: Student Learning

Model	β^1	Std. Error	β^2	*t*	Sig.	Collinearity Statistics VIF
(Constant)	2.666	.162		16.50	.000	
Math Rated Affect	.133	.034	.251	3.91	.000	1.538
Teacher Perception	-.102	.052	-125	-1.95	.051	1.538

1 Unstandardized coefficient
2 Standardized coefficient

Table 27 shows the correlation among student learning and the two factors: math rated affect and teacher perception. The correlation among the predictors was moderately related with a correlation coefficient of $r = 0.591$. In general, a moderate or strong correlation between the dependent variable and independent variables or predictors and a weak correlation among independent variables were sought.

Table 27

Correlations Among Student Learning and the Two Factors: Math Rated Affect and Teacher Perception

		Student Learning	Math Rated Affect	Teacher Perception
Pearson Correlation	Student Learning	1.000	.177	.023
	Math Rated Affect	.177	1.000	.591
	Teacher Perception	.023	.591	1.000

Since the correlation coefficients among predictors were moderately related, the researcher examined the multicollinearity index. The variance inflation factor (VIF) < 2.0 indicated no serious multicollinearity issue with the data set.

Q5 To what extent do pre-service teachers' attitudes toward math (effectance motivation, usefulness, math rated anxiety, teacher perception) relate to their beliefs in teaching mathematics?

The fifth research question was examined by conducting a multiple linear regression. The dependent variable was teaching math and the predictors were effectance motivation, usefulness of math, math rated affect, and teacher perception. All five predictors were included in the model for the first time. Multiple regression models based on stepwise, backward, and forward selection methods were generated as presented in Appendix H. Using the stepwise selection method, the final model included one predictor (effectance motivation) that could explain the dependent variable--teaching math. The result showed a significant relationship on pre-service teachers' beliefs in teaching math and effectance motivation (t = 5.72, p < 0.001). Table 28 shows results of the regression and the diagnostic analysis for teaching math. The adjusted R-squared was R^2_{adj} = 0.081, which meant less than 9% of the variation in teaching math was explained by the model.

Table 28

Multiple Linear Regression for the Dependent Variable: Teaching Math

Model	β^1	Std. Error	β^2	t	Sig.
(Constant)	2.877	.111		25.848	.000
Motivation	.189	.033	.289	5.724	.000

1 Unstandardized coefficient
2 Standardized coefficient

The Pearson correlation coefficient between teaching math and the effectance motivation was r = 0.289. In the initial model, the correlation among all the predictors was moderately related with correlation coefficients ranging between 0.339 and 0.782 (see Appendix H). Also, in the initial model, the researcher examined the multicollinearity index to determine whether there was a serious multicollinearity issue. The eigenvalues, the tolerance index, and the VIF all were low, indicating no serious multicollinearity issue. For example, the VIF was < 1.0.

Summary

This chapter presented the results of pre-service special, elementary, and secondary math education teacher' responses regarding beliefs and attitude toward mathematics and the learning and teaching of mathematics. A MANOVA was performed to find out if there were differences among participants' responses in belief and attitude toward math across academic year levels and majors. Also, multiple linear regression was performed to find out if there was a relationship between pre-service teachers' beliefs (student learning, teaching math) and attitudes toward math (math rated affect, effectance motivation, usefulness of math, teacher perception). In addition, chi-square was performed to examine whether there were significant differences in pre-service teachers' plans to teach math and their desirability to teach math across their majors. A summary of the results is presented as follow:

1. Differences were not statistically significant among pre-services teachers' academic year levels with regard to their beliefs and attitudes in mathematics.

2. Statistically significantly differences were found among pre-service teachers' beliefs and attitudes toward mathematics according to their academic majors. All the variables showed statistically significant differences among pre-service teachers' majors except student learning.
3. The relationship between major and planning to teach math was statistically significant. A statistically significant relationship was also found between major and desire to teach mathematics.
4. The regression analysis was statistically significant and there was a significant relationship found between pre-service teachers' beliefs in student learning and math rated affect. In addition, the relationship between pre-service teachers' beliefs in student learning and teacher perception approached significance.
5. A significant relationship was found between pre-service teachers' beliefs in teaching math and effectance motivation.

In the following chapter, these findings are discussed with regard to the research questions. Limitations, implications, and suggested future research are also addressed.

CHAPTER V

DISCUSSION

This research study was conducted to examine and compare the beliefs and attitudes of pre-service special and general education teacher candidates regarding mathematics and the learning and teaching of mathematics. A quantitative survey developed by the researcher--the Pre-Service Teachers' Beliefs and Attitudes Toward Mathematics scale (PSTBAM)--was administered to undergraduate education majors to examine their beliefs and attitudes about math and explore factors including student learning, teaching math, math rated affect (math anxiety and confidence), effectance motivation, usefulness of math, and teachers' perceptions. The interrelationship among these factors was explored and then compared to participants' academic levels (freshman, sophomore, junior, and senior) and academic majors (special, elementary, and secondary math education) to determine whether these factors might influence the approaches pre-service teachers think and believe in regarding teaching math and students' learning and that.

In this chapter, the findings from the current study are examined and discussed as they relate to each research question. The implications for current practice regarding mathematics education are presented, followed by suggestions for future research.

Research Question 1

The first research question sought to determine if there were differences between pre-service teachers' academic levels and their beliefs and attitudes in mathematics. Although some previous studies suggested pre-service teachers' beliefs and attitudes toward mathematics differed between academic levels (Dede & Karakus, 2014; Haciomeroglu, 2013; Haser & Doğan, 2012, Jackson & Leffingwell, 1999), the current study found no significant differences among pre-service teachers' academic levels and their beliefs in student learning and teaching math and their attitudes toward math including math rated affect, effectance motivation, usefulness of math, and teacher perceptions.

Perhaps the way in which this question was answered influenced the results. Data were obtained through combining all participants in one group without considering the interaction across their majors. Results might have been different if the researcher had considered this interaction or if each group of participants had been investigated separately (i.e., pre-service special education teachers alone) across their academic levels.

Research Question 2

The second research question aimed to determine if there were differences between pre-service teachers' major and their beliefs and attitudes in mathematics. Results from the current study revealed significant differences between pre-service teachers' majors and their beliefs and attitudes toward math on five factors including teaching math, math rated affect, usefulness of math, teacher perception, and effectance motivation but no significant difference was found between pre-service teachers' major and their beliefs in student learning. Discussion of the results of this research question is presented based on two constructs: beliefs and attitudes toward math (see Figure 3).

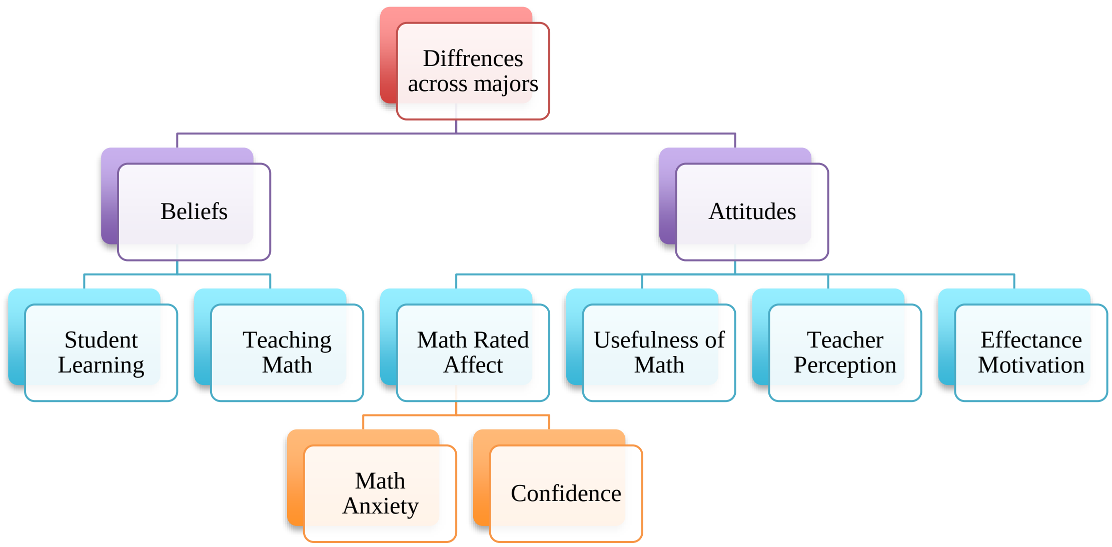

Figure 3. Two constructs: beliefs and attitudes.

Beliefs in Student Learning and Teaching Math

Results of the current study indicated no significant difference between pre-service teachers' major and their beliefs in student learning. However, a significant difference was found between pre-service teachers' major and their beliefs in teaching math. Pre-service teachers in secondary math education had higher mean scores in teaching math than pre-service teachers in special and elementary education. These significant differences among pre-service teachers in their beliefs in teaching math might be explained by the effect and impact of their preparation programs and/or the way their math teachers taught them math. However, although the pre-service secondary math teachers had higher mean scores, findings showed all pre-service teachers in all three programs believed the approaches and practices used in teaching math should be based on a constructivist approach.

Results also showed pre-service special education teachers had higher mean scores in teaching math than did pre-service elementary education teachers. Interestingly, pre-service special education teachers believed in a more constructivist approach to teaching math than elementary education pre-service teachers. These findings contradicted some previous research findings (Durmas & Bicak, 2006; Klein, 2001; Mewborn, 2001). For instance, Klein (2001) found pre-service teachers considered teaching math was based on a traditional approach to math instruction whose emphasis followed certain rules and procedures.

It was also interesting to find all pre-service teachers from the three programs shared similar beliefs about how students should learn mathematics--they believed using a traditional approach was the most effective way to learn math. At the same time, the participants in this study also believed in using a more constructivist approach when teaching math. It seemed pre-service teachers' beliefs in student learning contradicted their beliefs in teaching math. The researcher had anticipated some consistency between learning and teaching beliefs. Green (1971) provided an explanation for why people could hold contradicting beliefs. He stated that an individual's belief system is complex and different beliefs could be organized into different clusters. Thus, beliefs that appear to be mutually contradicting might actually belong to two different clusters--one as learning and the other as teaching.

Previous research findings indicated what future teachers experienced in their past academic schools including elementary, secondary, and even more in their pre-service education preparation affected and shaped their beliefs. Two particular factors--prior experiences with math and math knowledge--that might explain the current study participants' responses regarding their beliefs about students' learning and teaching math are discussed.

Prior experiences with math. Previous research findings indicated the types of instruction future teachers experienced in their own academic career as well as in their pre-service education preparation affected and shaped their beliefs (Bekdemir, 2010; Brady & Bowd, 2005; Mulcahy et al., 2014; Nicol et al., 2002). Pre-service teachers who had negative experiences in their mathematics classes were more likely to hold negative beliefs and attitudes about mathematics.

Slightly more than 40% of the participants in the current study had negative experiences in their math classes in high school; few of them experienced and learned math in the secondary education level by emphasizing on understanding math concepts and seeking to learn the actual meaning behind math concepts (constructivist approach). For example, about 40% of the special education pre-service teachers, 45.7% of the elementary education pre-service teachers, and 41.9% secondary math pre-service teachers agreed their teachers used constructivist methods when teaching math; used strategies that included manipulatives, visual aids, and cooperative learning; emphasized an understanding of the actual meaning behind math concepts; and focused on following rules and memorizing facts. Many studies indicated previous school experience influenced beliefs (Bekdemir, 2010; Brady & Bowd, 2005, Ernest, 1989), especially during their secondary level (Nicol et al., 2002; Trujillo & Hadfield, 1999) and continued throughout their future professional development (Pugh et al., 2010).

Math knowledge. In light of discussing the findings of the current study, it is important to mention all three programs--special, elementary, and secondary math education--have different curricula. Participants reported the secondary math education program includes more math content and method courses than either elementary or special education programs/majors. Additionally, findings showed participants from the secondary math education pre-service teacher program had higher level high school mathematics as well as higher GPA scores than the special and elementary pre-service teachers.

Attitude Toward Math

When it came to attitudes about math, the findings of the current research showed significant differences among the three academic majors for the four factors of math rated affect, effectance motivation, teacher perception, and usefulness of math. Findings showed pre-service teachers in secondary math education had higher mean scores than pre-service teachers in special and elementary education on all four factors. Also, pre-service teachers in elementary education had higher mean scores in math rated affect and usefulness of math than pre-service teachers in special education. This finding aligned with previous research that indicated attitudes toward mathematics differed between pre-service teachers' academic programs (Johnson & vanderSandt, 2011; Maccini & Gagnon, 2002, 2006; Malinsky et al., 2006). Additionally, prior studies (Daniels et al., 2013; Dede, 2015; Dede & Karakus, 2014; Malinsky et al., 2006; Peker, 2009, Wilkins, 2008) proposed pre-service teachers' type of program (i.e., elementary, secondary) potentially influenced teachers' teaching anxiety, mathematics educational values, beliefs, and motivation.

Generally, findings indicated pre-service special education teachers held mixed to positive attitudes toward math in all combined four factors: math rated affect, effectance motivation, usefulness of math, and teacher perception. However, elementary and secondary math education teachers held more positive attitudes toward math on the same factors . In the following section, the results regarding each of these factors in relation to pre-service teachers' majors are discussed in more detail.

Math rated affect (math anxiety and confidence). When it came to math anxiety and confidence, the current study's results showed significant differences between participants from all three majors in math rated affect in favor of secondary math education pre-service teachers. Also, findings revealed elementary education pre-service teachers had higher mean scores in math rated affect than special education pre-service teachers. When math rated affect was examined as two separate factors (confidence and math anxiety), results showed pre-service special education teachers had higher levels of math anxiety, elementary pre-service teachers had less anxiety, and secondary math educators had the least anxiety about math. With regard to the confidence factor, findings indicated special and elementary pre-service teachers were less confident when compared to secondary math education pre-service teachers who were more confident and positive about their ability in math. Research (Johnson & vanderSandt, 2011; Maccini and Gagnon, 2002) suggested teachers in general education hold more positive attitudes toward mathematics than teachers in special education.

Although the current research did not focus on investigating whether a relationship existed between math anxiety and confidence, a Pearson correlation indicated a moderate to strong relationship existed between math anxiety and level of confidence among pre-service teachers. This finding aligned with other research findings that demonstrated a negative relationship between math anxiety and confidence (Cardetti & Truxaw, 2014; Swars et al., 2009); the less math anxiety shown by pre-service teachers, the more confident they felt about their math abilities. Researchers and educators have paid considerable attention to this matter because many teachers who feel more anxiety about math are more likely to transfer those feelings to their students and impact their performance (Beilock et al., 2009; Furner & Berman, 2005; Stipek et al., 2001) and influence teachers' ways and performance of teaching math (Briley, 2012; Bursal & Paznokas, 2006; Haciomeroglu, 2013).

Findings from the current research found the highest level of high school math completed by special education pre-service teachers was lower than that of elementary and secondary math education pre-service teachers. Not surprisingly, secondary math education pre-service teachers had completed more math courses during high school in comparison to the other two participant groups. In addition, by reviewing participants' high school GPA scores in math and SAT or ACT scores in the math section, it was evident secondary math education majors had higher scores in comparison to the other groups. The special education pre-service teachers took fewer math courses during their preparation program than the pre-service teachers who specialized in elementary or secondary math education. Also, the majority of elementary and secondary math education pre-service teachers described their math ability and knowledge as good, whereas special education pre-service teachers described their math and knowledge ability as acceptable. These results might explain pre-service teachers' math anxiety and confidence in their math ability, especially pre-service special education teachers who were likely to be the least knowledgeable in math. Previous research indicated beliefs, attitudes, and perceptions toward math are related to an individual's ability and knowledge in math (Campbell et al. 2014; Charalambous, 2015; Philipp, 2007; Swars et al., 2007; Wilkins, 2008). The current findings aligned with results of Mulcahy et al. (2014) who found many special education teachers had limited classroom experience in learning mathematics and demonstrated only limited math proficiency. Furthermore, Maccini and Gagnon (2006) found special education teachers were less knowledgeable about higher-level mathematics content, such as algebra, and were less likely to use specific instructional practices and assessment accommodations.

Acquiring sufficient mathematics content and knowledge explained the positive beliefs and attitudes toward math demonstrated by pre-service secondary math education teachers (Campbell, et al., 2014; Charalambous, 2015). The more math content and knowledge acquired by pre-service teachers, the less math anxiety they will feel (Brady & Bowd, 2005; Johnson & vanderSandt, 2011). Thus, pre-service teachers with sufficient math content and knowledge are more likely to hold positive beliefs and attitudes toward math, feel less anxious about math, and are more confident about their ability in teaching math. However, Copple (2004) pointed out many universities and colleges in the United States have only minimum math requirements in early education programs (generally thought to encompass preschool through age eight). It is important that teachers be highly qualified whether they are secondary math education, elementary, or special education teachers. The IDEA (2004) stated highly qualified special education teachers means they have “full state certification,” “hold license to teach,” “at least a bachelor’s degree,” and “demonstrate subject matter competence in academic subjects” (p. 1). Therefore, teacher preparation programs, especially special and elementary education programs, must consider providing more math content and methods courses to reduce math anxiety and increase pre-service teachers’ confidence in their math abilities.

Usefulness of math. Value can be shown as engaging in the task and holding a belief that the task will achieve individual goals. Value is portrayed in several types including intrinsic value, utility value (usefulness), and cost. These components are important to determine learners’ motivations and achievements. In addition, learners’ beliefs of intrinsic and utility value are directly interrelated to task interest and performance. Furthermore, the review of literature illustrated the relationship between utility value and achievement and how utility value predicted learner interest and performance, particularly in mathematics. Teachers who believe mathematics is useful in life often employ more effective instructional methods when teaching math (Briley, 2012). Although several studies have investigated students’ beliefs in the value of math (Briley, 2012; Chouinard & Roy, 2008; Gaspard et al., 2015), limited research examined these values (i.e., usefulness of math) as seen by pre-service teachers attitudes toward mathematics.

The current study found a significant difference between secondary math education and both special and elementary education pre-service teachers in usefulness of math. Secondary math education teachers had higher mean scores in usefulness of math than pre-service teachers in special and elementary education. On the other hand, findings showed elementary pre-service education teachers had higher mean scores in usefulness of math than pre-service special education teachers. One possible reason that might explain these findings was teachers' exposure to math content and concepts prior to entering their teacher education program. Secondary math education pre-service teachers indicated they had more math content experience. Data also showed secondary math education pre-service teachers were more likely to learn math from previous math teachers who stressed understanding math concepts, which includes knowing math applications and recognizing the employment of math concepts in real life.

Teacher perception. This factor measured pre-service teachers' perceptions of how previous teachers (secondary math teachers) felt about them as learners. What pre-service teachers experienced during their past mathematics classes, especially at high schools, and their teachers' behaviors were factors linked to math anxiety and lack of confidence in mathematics, both of which could result in negative beliefs and attitudes toward math. Findings of the current study revealed a significant difference between secondary math education pre-service teachers and both special education and elementary pre-service education teachers. Secondary math education pre-service teachers had higher mean scores in teacher perceptions than pre-service teachers in special and elementary education. This finding suggested that secondary math pre-service teachers felt more positive about their ability to do math due to the support they received from previous secondary math teachers. Having the support portrayed as teachers' belief in their students as math learners might have a potential influence on students' career choices, i.e., becoming secondary math education teachers. In addition, findings showed no significant difference between special and elementary pre-service education teachers in teacher perceptions. The lowest mean was associated with special education pre-service teachers. This finding might indicate special and elementary pre-service teachers had similar experiences with previous math teachers during their secondary level.

A question that arose from these findings is why secondary math education pre-service teachers had the most positive experiences with previous math teachers. Of note was the secondary math pre-service teacher group had more male participants than the other two groups and that gender might be a factor related to positive experiences. It is possible the students' gender influenced their math teachers' perceptions about their students' math ability, which in turn resulted in more positive experiences among the male students. Riegle-Crumb and Humphries (2012) found high school teachers believed math was easier for White male students than for White female students. Furthermore, a study by Fennema, Peterson et al. (1990) revealed that teachers tended to overestimate male students' math abilities and skills whereas these teachers tended to underestimate female students' math abilities and skills.

The findings revealed significant differences among pre-service teachers' responses in teacher perception. Data revealed the participants had positive experiences with previous secondary math teachers and felt their teachers believed in their students' skills and ability to do math. This finding aligned with previous research (Brady & Bowd, 2005; Brown & Borko, 1992; Bruce, 2004).

Effectance motivation. Motivation is considered the engine that drives individual behaviors and is an essential component in determining human success in all aspects of life. Intrinsic motivation is one type of motivation, which is determined by self-report of enjoyment and interest in the task itself. In the current study, effectance motivation measured the interest or enjoyment of math. Findings revealed a significant difference between the secondary math education pre-service teachers and the other two groups--special education and elementary pre-service education teachers--in effectance motivation. Secondary math education teachers had higher mean scores in effectance motivation than pre-service teachers in special and elementary education. Findings also showed no significant difference in effectance motivation between special and elementary pre-service education teachers. Special and elementary pre-service teachers had mixed feelings about their motivation toward math. The highest mean was associated with secondary math education teachers and the lowest mean was associated with special education pre-service teachers.

Two possible reasons might explain the difference among pre-service teachers' majors in effectance motivation. First, pre-service teachers' academic achievement in math might contribute to their math motivation and vice versa. Findings by Muis (2004) revealed significant positive relationships between motivation and academic achievement. The second reason might be the opportunity secondary math education teachers have had to choose one subject and specialize in that choice. They chose their major and they knew one of their responsibilities would be to teach math in their future career.

Results of effectance motivation might also be related to the participants' responses to research question three. In the following research question, the differences among participants on planning to teach math and desirability to teach math are discussed.

Research Question 3

The third research question was divided into two sub questions. The first sub-question sought to determine if there were differences in pre-service teachers' plans to teach math across their major (special, elementary, and secondary math). Findings showed all of the pre-service teachers in secondary math education were planning to teach math. However, this was not the case for elementary and special education pre-service teachers. Around two-thirds of special education pre-service teachers (64.5%) were not planning to teach math whereas around a quarter (22.5%) of elementary education pre-service teachers were not planning to teach math. This finding is a concern as a large number of special and elementary pre-service teachers did not think teaching math would be part of their responsibilities as future teachers. Yet in reality, many elementary pre-service teachers are expected to teach many subjects including math. The results indicated some of the elementary pre-service teachers thought and believed they would not be expected to teach math because they did not specifically choose to focus on teaching it. An implication of this finding was elementary education pre-service teachers need to know more about their future roles as elementary teachers and their responsibility to teach math as one of the required subjects.

The most concerning finding from this research question was undoubtedly that only one third of the special education pre-service teachers were planning to teach math. Descriptive data indicated that of the three groups of participants, special education pre-service teachers had the lowest math-related SAT, ACT, and GPA scores from high school; took the fewest number of math courses during their program; and had the lowest self-rating of math abilities of the three groups. Given their future job would be to assist students who did not meet grade level standards in any subject through specialized instruction and interventions, it was interesting that so many of these pre-service teachers were not planning to teach one of the three core academic subjects. The IDEA (2004) requires all special education teachers be highly qualified to teach in their subject area; however, it appears the focus of many pre-service teacher programs is on instructional strategies such as differentiating instruction and familiarity with current evidence-based practices rather than on mastery of the core subjects. Because they will most likely be expected to provide individualized instruction in math as well as in literacy, pre-service special education teachers need to have a strong foundation in math. Without this, research suggested their motivation and interest in teaching math as well as their ability to engage their students, will in all likelihood be less (Midgley et al., 2000; Muis, 2004; Perry, 2011).

The second sub-question sought to determine whether there were differences in pre-service teachers' desire to teach math across their major (special, elementary, and secondary math). Not unexpectedly, the results showed all (100%) pre-service teachers in secondary math education wanted to teach math. However, more than half (60.3%) of special education pre-service teachers and more than a third (39.2%) of elementary education pre-service teachers did not desire to teach math. This might be explained by many factors such as their attitudes toward math, motivation, math ability and knowledge, and teaching skills.

Again, it was quite concerning that more than half of the special education pre-service teachers as well as close to half of the elementary education pre-service teachers did not want to teach math. This lack of desire and motivation to teach an important core subject could have a significant negative impact not only on students' perceptions of math but also on their future attitudes and achievements. Research showed when students had teachers who were knowledgeable, well prepared, and enthusiastic about teaching, they became more engaged and demonstrated higher levels of learning (Alexander et al., 2007; Campbell et al., 2014). Regardless of whether students perform at grade level or have disabilities, all students deserve to have good experiences learning math from teachers who are highly qualified and enthusiastic about teaching math.

Research Question 4

For this research question, the researcher examined the relationship between pre-service teachers' beliefs in student learning and attitudes toward math including effectance motivation, usefulness of math, math rated affect, and teacher perception. Findings of the current study revealed a positive relationship between student learning and math rated affect (math anxiety and confidence). This finding indicated participants who believed in a constructivist approach toward learning math were more likely to experience less math anxiety and were more confident about their own math abilities. In addition, another interesting finding was the correlation between teacher perception and student learning was not significant. The researcher was expecting to find a relationship between these factors but the limitations of the study (i.e., sample size and the characteristics of the sample) and the teacher perception construct could have influenced the results. Thus, further research could explore these avenues.

Findings also revealed math rated affect and teacher perception could predict pre-service teachers' beliefs in student learning. This implies that what pre-service teachers experienced in school, particularly during high school such as previous math teachers' perceptions, the level of math anxiety and confidence had the potential to predict their beliefs of how students should learn math. In another words, pre-service teachers who experienced less math anxiety and more confidence in their math ability were more likely to believe in a constructivist approach in student learning. Remarkably, a finding from the model indicated pre-service teachers who had negative experiences with their previous math teachers were more likely to believe in a constructivist approach in student learning. This finding was not expected and could be explained by the suggestion that pre-service teachers who had negative math experiences were more likely to adopt a different approach from what they had experienced and were more willing to provide their students with positive math experiences in their future career. This finding aligned with the findings of Anderson et al. (2005) who found an opposing relationship between teachers' beliefs regarding previous experiences and practices.

The current findings supported the results of previous research regarding a relationship between pre-service teachers' beliefs in math and their beliefs in practices and approaches (Cross, 2009; Holm & Kajander, 2012; Rosas & West, 2011). Researchers also found pre-service teachers' experiences and interactions with previous teachers affected their beliefs toward math (i.e., Bekdemir, 2010; Brady & Bowd, 2005; Jackson & Leffingwell, 1999; Uusimaki & Nason, 2004). In addition, previous research found a relationship among learning math, math anxiety, and holding negative beliefs about math (Uusimaki & Nason, 2004). Although prior research found a relationship between learning math and usefulness of math (Fennema & Sherman, 1976), the current study did not find a relationship between beliefs in student learning and usefulness of math.

Therefore, it seems obvious that having math teachers with less math anxiety, more confidence about their math ability, and a strong belief in using a variety of instructional approaches to meet students' different math learning styles would benefit all students. It is important that teachers at all academic levels understand the influence they have on their students' beliefs and attitudes about math as well as their level of anxiety and confidence. In particular, math teachers at the secondary level need to consider the power of their perceptions upon their own students' math abilities. It is worth remembering here that the participant group who reported the highest levels of teacher perception were those in the secondary math education pre-service teacher program. Their academic success in high school was at a minimum one factor that influenced their career choice as adults.

The current study aimed to examine the relationship between beliefs and attitudes in contrast to previous studies that explored the relationship between beliefs and practices. The researcher considered Green's (1971) speculation about belief system when conducting the current study. It seemed it was not necessary to have a connection between the clusters of the belief system. Leatham (2006) proposed that belief systems are sensible systems. It was very challenging to frame the concept of belief or even agree on certain definitions. Belief systems are complex and some researchers suggested belief and attitude have similar components and might be considered one concept.

Research Question 5

The final research question of this study examined whether there was a relationship between pre-service teachers' beliefs in teaching math and their attitudes toward math including effectance motivation, usefulness of math, math rated affect, and teacher perception. Findings revealed a positive relationship between teaching math and effectance motivation. It appeared pre-service teachers with high levels of effectance motivation in math were more likely to believe teaching math should include different methods and were more likely to hold beliefs in constructivist approaches in teaching math.

These findings suggested effectance motivation could predict pre-service teachers' beliefs in teaching math. However, it ws important to report the relationship found between teaching math and effectance motivation was weak and the R-square value was low. This is not uncommon in research involving predictions of human behavior as human behavior relies on a number of different factors. However, important conclusions can still be drawn with regard to how changes in the values of a predictor are linked to changes in the value of response.

No studies were found that investigated the relationship between beliefs in teaching math and factors including effectance motivation, usefulness of math, math rated affect, and teacher perception. However, several studies assumed the relationship between beliefs and attitudes about mathematics was held by teachers and their teaching practices (Beghetto, 2008; Briley, 2012; Campbell et al., 2014). For example, Briley (2012) found math self-efficacy was positively related to math teaching efficacy and math beliefs and self-efficacy positively predicted math-teaching efficacy. Other studies found a relationship between teaching math and math anxiety (Yazici et al., 2011). Furthermore, Middleton and Spanias (1999) and Perry (2011) found a relationship between mastery goals and intrinsic motivation. Perry's results also revealed a positive relationship among mastery goals and the three constructs of attitude: confidence in learning mathematics, usefulness of mathematics, and mathematics as a male domain.

Limitations

There were some limitations to the present research study. The use of a small, non-representative convenience sample limited the ability of the results to be generalized to all pre-service teachers. The sample consisted of three groups of participants; while there were 121 participants in the special pre-service teacher education group and 210 participants in the elementary pre-service teacher education group, there were only 31 participants in the secondary math education pre-service teacher group. This limited the researcher's ability to explore differences and/or changes in attitudes and beliefs for each major across academic level (freshman, sophomore, junior, and senior).

In addition, using a sample from a single university might have limited the range of participant responses, thereby affecting the generalizability of the findings. Different universities have different teacher education programs based in part on different licensure requirements. For instance, some teacher education programs lead to licensure in special education as a stand-alone license while others lead to dual certification in elementary education and special education. Pre-service teachers attending two very different teacher education programs would likely have different academic experiences as well as different expectations regarding a future career.

Implications

A striking finding from the current study was the fact that nearly two-thirds of the special education pre-service teachers did not expect nor want to teach math once they became teachers. Given that math is one of the three main content areas of any education curriculum in the United States, this was concerning. Of the three groups of participants in this study, secondary pre-service teachers had the highest levels of math rated affect, effectance motivation, teacher perception, usefulness, and beliefs in teaching math while special education pre-service teachers had the lowest levels. This discrepancy in attitudes and beliefs towards math might be reflected in their plans to teach math.

Educators at the university level need to be aware of their students' beliefs and attitudes toward math and how these might affect their students' motivation to teach math. By assessing pre-service teachers' beliefs and attitudes at the start of their preparation programs, educators could put into place interventions that support and engage their pre-service teachers, especially those with high math anxiety, less confidence, less interest and motivation, as well as those who hold traditional beliefs in learning and teaching math. The most common interventions could consist of offering more content-based math coursework to increase pre-service teacher knowledge and skills in math, increased field experiences related to math, and including activities such as reflections and biography in current math classes. Additionally, all pre-service teacher preparation programs might need to include classes that focus on constructivist methods that emphasize understanding math concepts and conceptualization as well as traditional strategies to ensure pre-service teachers have a solid foundation in using a wide array of instructional approaches. Ensuring all pre-service teachers have strong content knowledge and are prepared to teach math might lead to more positive beliefs and attitudes towards math. Special education teachers in particular need to use a wide variety of strategies to meet the unique learning needs of their students. Therefore, providing pre-service teachers with hands-on experience in a range of approaches might give them the experience as well as the content knowledge they need to become effective teachers.

Another interesting finding from the current study was the discrepancy between pre-service teachers' beliefs in teaching math and student learning. Although all three participant groups believed math was best taught using constructivist methods, at the same time they thought students learned best when taught with a more traditional approach. Because beliefs about student learning are rooted in pre-service teachers' previous experience with learning math, providing them with experiences in using different approaches might help evolve their beliefs. Different approaches to addressing negative beliefs include not just exposure to alternative belief systems but also in carefully designing ways to help pre-service teachers think about and question their own existing belief systems without alienating them or increasing their persistence in their own negative beliefs. One strategy would be to increase practical and supervised field experiences for pre-service teachers, particularly exposing them to successful classroom teaching environments that reflect a positive attitude about learning math within a constructivist approach. Adding reflective activities during and after field experiences could also enhance the development of positive beliefs and attitudes, particularly as pre-service teachers examine and compare ways they themselves were taught with those presented in field experiences.

Future Research

It is clear more information is needed about the role of special education math teachers as well as prior experiences with math and their preparation programs. This research area has received little attention and yet special education teachers are responsible for providing specialized instruction in math as well as other content areas to students with a range of learning challenges. To better understand how to address the needs of these students and their teachers alike, research is needed to explore the beliefs, attitudes, and experiences of pre-service as well as in-service special education teachers with regard to math. Such research could help shed light on new ways to improve the performance of students with special needs in math knowledge and skills. Longitudinal research would be particularly helpful in exploring changes in teachers' beliefs and attitudes over time.

The current study revealed nearly two-thirds of pre-service special education teachers did not plan nor want to teach math in the future. Of the pre-service elementary teachers, two-fifths did not want to teach math. Research is needed to explore the career expectations of pre-service teachers, their motivation to become a teacher, and how discrepancies between expectations and realities affected their job satisfaction.

Research is also needed into interventions that alter pre-service teachers’ negative perceptions and attitudes toward math and support them in developing effective pedagogical strategies as well as content knowledge for teaching mathematics. Findings of the current study revealed factors such as math rated affect, teacher perception, and motivation might have the potential to predict beliefs in learning and teaching math. Thus, this relationship between beliefs and attitudes might help educators at the university level anticipate pre-service teachers’ beliefs by identifying math anxiety, confidence, previous math experience, and their motivation and interest in math.

Finally, some universities provide integrated pre-service teacher preparation programs in general and special education that results in dual licensure. Research is needed to examine the effectiveness of such an integrated approach in preparing teachers to teach mathematics for all students in inclusive settings.

Conclusion

One contribution of the current study was to provide data of beliefs and attitudes in math and math background of three different majors and more specifically about special education pre-service teachers. Very limited to little research has been conducted specific to pre-service special education teachers' beliefs and attitudes in math. This study might help educators in university teacher preparation programs assist their pre-service teachers in changing existing negative beliefs and attitudes toward math.

Another contribution of the current study was this research added to the literature in the field of education, specifically special education. Prior to this study, very limited research investigated pre-service special education teachers and compared this population with other groups such as elementary and secondary math pre-service teachers. Although several studies have investigated teachers' beliefs and attitudes toward math, little research has been conducted regarding special education teachers. Additionally, at this time, no research was found examining pre-service teachers' beliefs and attitudes in math as assessed by many factors.

Finally, this study provided information about whether pre-service special education teachers planned and desired to teach mathematics compared with the other two participant groups--elementary education and secondary math education pre-service teachers. No previous research study was found that addressed this question. By extending the research to include special education pre-service teachers, it is clear this population might need more support to become highly effective teachers in all content areas.

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APPENDIX A

PRE-SERVICE TEACHERS' BELIEFS AND ATTITUDES IN MATHEMATICS AND LEARNING AND TEACHING MATHEMATICS SURVEY

Pre-Service Teachers' Beliefs and Attitudes in Mathematics and Learning and Teaching Mathematics (PSTBAM)

Instructions to be read to participants:

The following questionnaire consists of several statements that you may or may not agree with. You are asked to determine how strongly you feel about the statement below. The items are ranked from *strongly disagree* to *strongly agree*. Please select and circle one of the five choices for each question. There are no right or wrong answers.

Please answer these items *as accurately as possible.* Take as much time as you need to answer each of the questions. Be sure to find an answer for every statement **but circle one response only at the right of each statement.**

Tell me about your thoughts of how children should learn math by responding to the following items (1-6):

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1- L1	Children should master ***math procedures*** before they are expected to understand how those procedures work.	1	2	3	4	5
2- L2	Time should be spent practicing ***math procedures*** before children are expected to understand the procedures.	1	2	3	4	5
3- L3	Children ***will not*** understand an operation (addition, subtraction, multiplication, or division) until they have mastered some of the relevant number facts.	1	2	3	4	5
4- L4	Recall of number facts should precede the development of an understanding of the related operation (addition, subtraction, multiplication, or division).	1	2	3	4	5

5- L5	Children ***should not*** solve simple word problems until they have mastered some number facts.	1	2	3	4	5
6- L6	Time should be spent practicing ***math procedures*** before children spend much time ***solving problems***.	1	2	3	4	5

Tell me about your thoughts of how teachers should teach math by responding to the following items (1-6):

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
7-TM1	Teachers should allow children who are having difficulty solving a math problem to continue to try to find a solution.	1	2	3	4	5
8-TM2	Teachers should encourage children to find their own solutions to math problems even if they are inefficient.	1	2	3	4	5
9-TM3	Mathematics should be presented to children in such a way that they can discover relationships for themselves.	1	2	3	4	5
10-TM4	Teachers should teach exact ***procedures*** for ***solving math problems***.	1	2	3	4	5
11-TM5	The goals of instruction in mathematics are best achieved when students find their own methods for solving problems.	1	2	3	4	5
12-TM6	Teachers should allow children to figure out their own ways to solve simple math problems.	1	2	3	4	5

Tell me about your confidence to learn and to perform in mathematics tasks by responding to the following items (1-4):

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
13-C1	Generally I have felt secure about attempting mathematics.	1	2	3	4	5
14-C2	I'm ***not*** good at math.	1	2	3	4	5
15-C3	For some reason even though I study, math seems unusually hard for me.	1	2	3	4	5
16-C4	Most subjects I can handle OK, but I have a knack of messing up in math.	1	2	3	4	5

Tell me about your feelings about math by answering the following items (1-5):

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
17-A1	I usually feel at ease in math classes.	1	2	3	4	5
18-A2	Mathematics usually makes me feel ***un***comfortable and nervous.	1	2	3	4	5
19-A3	Mathematics makes me feel restless, irritable, and impatient.	1	2	3	4	5
20-A4	I get worried when I think of solving math problems.	1	2	3	4	5
21-A5	Mathematics makes me feel uneasy and confused.	1	2	3	4	5

<u>Tell me about your motivation in acquiring more mathematical experience and challenges, and your enjoyment and interest of mathematics by answering the following items (1-12):</u>

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
22-M1	I like math puzzles.	1	2	3	4	5
23-M2	Mathematics is enjoyable and stimulating to me.	1	2	3	4	5
24-M3	When a math problem arises that I can't immediately solve, I stick with it until I have the solution.	1	2	3	4	5
25-M4	Once I start working on a math puzzle I find it hard to stop.	1	2	3	4	5
26-M5	When a question is left unanswered in math class, I continue to think about it afterward.	1	2	3	4	5
27-M6	I am challenged by math problems I can't understand immediately.	1	2	3	4	5
28-M7	Figuring out mathematical problems ***<u>does not</u>*** appeal to me.	1	2	3	4	5
29-M8	The challenge of math problems ***<u>does not</u>*** appeal to me.	1	2	3	4	5
30-M9	Math puzzles are boring.	1	2	3	4	5
31-M10	***<u>I don't</u>*** understand how some people can spend so much time on math and seem to enjoy it.	1	2	3	4	5
32-M11	I would rather have someone give me the solution to a difficult math problem than have to work it out for myself.	1	2	3	4	5
33-M12	I do as little work in math as possible.	1	2	3	4	5

<u>Tell me about how your math teachers thought about you as learner (*especially secondary math teachers*) by responding the following items (1-6):</u>

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
34-T1	My math teachers think I'm the kind of person who could do well in mathematics.	1	2	3	4	5
35-T2	My math teachers made me feel I have the ability to go on in mathematics.	1	2	3	4	5
36-T3	My math teachers were interested in my progress in mathematics.	1	2	3	4	5
37-T4	I found it hard to win the respect of my math teachers.	1	2	3	4	5
38-T5	Getting a mathematics teacher to take me seriously usually has been a problem.	1	2	3	4	5
39-T6	I had a hard time getting teachers to talk seriously with me about mathematics.	1	2	3	4	5

<u>Tell me about your thoughts of the usefulness of math in relationship to your future life, vocation, or other activities by responding to the following items (1-12):</u>

Item No.	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
40-U1	I'll need mathematics for my future work.	1	2	3	4	5
41-U2	I study mathematics because I know how useful it is.	1	2	3	4	5
42-U3	Knowing mathematics will help me earn a living.	1	2	3	4	5
43-U4	Mathematics is a worthwhile and necessary subject.	1	2	3	4	5
44-U5	I'll need a firm mastery of mathematics for my future work.	1	2	3	4	5
45-U6	I will use mathematics in many ways as an adult.	1	2	3	4	5
46-U7	Mathematics is of ***<u>no</u>*** relevance to my life.	1	2	3	4	5
47-U8	Mathematics ***<u>will not</u>*** be important to me in my life's work.	1	2	3	4	5
48-U9	I see mathematics as a subject I will rarely use in daily life.	1	2	3	4	5
49-U10	Studying mathematics is a waste of time.	1	2	3	4	5
50-U11	In terms of my adult life it ***<u>is not</u>*** important for me to do well in mathematics in school.	1	2	3	4	5
51-U12	I expect to have little use for mathematics when I get out school.	1	2	3	4	5

Demographic Information

Academic major:

☐ Special Education Generalist (K-12)
☐ Special Education Early Childhood (age birth-8)
☐ Elementary Education (K-6)
☐ Secondary Math Education (7-12)
☐ Other. If other, what is your content area of study?.................

Year in School (program):

☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior

Are you planning on teaching math?

☐Yes ☐ No

How desirable is it for you to teach math?

☐ Strongly Not Desirable
☐ Not Desirable
☐ Desirable
☐ Strongly Desirable

What is your highest level of high school mathematics? *(Please choose only one option)*

☐ Algebra 1 ☐ Algebra 2 ☐ Geometry ☐ Trigonometry
☐ Pre-calculus ☐ Calculus ☐ Other. If other, what class?..................................

How do you describe your math ability and knowledge?

☐ Very Poor ☐ Poor ☐ Acceptable ☐ Good ☐ Very Good

How many math courses (i.e., math method, math content) have you taken in your program (undergraduate study)?

……………………………………………………………………………………………

My high school average scores in Mathematics:

☐ < 2.0 ☐ 2.0-2.5 ☐ 2.6-3.0 ☐ 3.1-3.5 ☐ 3.6-4.0

Overall high school grade point average (GPA)

☐ ˂ 2.0 ☐ 2.0-2.5 ☐ 2.6-3.0 ☐ 3.1-3.5 ☐ 3.6-4.0

What was your score on the *math section* of the SAT/ACT?

If **SAT**:……………………………/If **ACT**:……………………………..

What is your ethnic background? (Please choose only one)

☐ American Indian ☐ Asian or Pacific Islander ☐ Caucasian
☐ Hispanic ☐ African-American ☐ Middle Eastern
☐ Other. If other, what ethnicity? …………………….
☐ Prefer not to answer

Gender:

☐ Female ☐ Male

What is your age?

☐ 18-22 ☐ 23-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 41-50 ☐ 51+

Mathematics is a male domain:

☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree

I received the support in math from my:

☐ Mother ☐ Father ☐ Both ☐ Neither

I had negative school experience in math classes:

☐ Yes ☐ No

If yes, which school level?

☐ Elementary school ☐ Middles school ☐ High school

☐ College

My math teachers, at the *secondary school level*, taught math by:

a) Using variety of ways and strategies (i.e., manipulatives, visual aids, cooperative learning).
b) Emphasizing an understanding of the actual meaning behind math concepts.
c) Focusing on following rules and memorizing facts.
d) All the previous options
e) Options A and B
f) Options A and C
g) Options B and C

Thank you

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE: June 12, 2017

TO: Bedoor Alazemi
FROM: University of Northern Colorado (UNCO) IRB

PROJECT TITLE: [1079182-2] Exploring pre-service special and general education teachers' beliefs and attitudes in mathematics and learning and teaching mathematics
SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVAL/VERIFICATION OF EXEMPT STATUS
DECISION DATE: June 10, 2017
EXPIRATION DATE: June 10, 2021

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

Hello Bedoor,

Thank you for the quick return of your modifications. Everything looks good and your IRB application is approved. Good luck with your research.

Sincerely,

Nancy White, PhD, IRB Co-Chair

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.

APPENDIX C

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH

UNIVERSITY OF
NORTHERN COLORADO

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH
UNIVERSITY OF NORTHERN COLORADO

Project Title: Exploring Pre-Service Special and General Education Teachers' Beliefs and Attitudes in Mathematics and Learning and Teaching Mathematics

Researcher: Bedoor Alazemi, MA, School of Special Education

Research Advisor: Dr. John Luckner
Work Phone: (970) 351-1672 E-mail: John.Luckner@unco.edu

I am a student in the School of Special Education at the University of Northern Colorado (UNC). I am interested in finding out pre-service teachers' beliefs and attitude regarding mathematics. I ask that you participate in this project, which will involve a survey as a tool to obtain your opinions. Estimated time to complete the survey should be no more than 20 minutes. Please know that I intend to keep the contents of the survey secure. The survey will be stored in locked file cabinets in the Researcher's locked office for 3 years. All electronic files related to the study, including Excel files, SPSS analyses, field notes, and emails pertaining to the study will be kept on a password-protected computer. At no point will you be identified because you will not provide your name. Computer files of the survey will be created with numerical identifiers. No participants' names will appear in any professional report of this research. All results will all be reported in aggregate form so that individual responses cannot be identified.

Risks to you are minimal and are no greater than those normally encountered during regular classroom participation. For example, the participant may have discomfort or stress similar to when they may engage in a answering a survey. The results of the survey will not affect your course grade. Participants may be intrinsically rewarded by contributing and providing relevant data to the field of special education. Additionally, participants might feel rewarded by indirectly participating in the decision-making process by providing their perceptions and understanding of the current situation with math education to the policy-makers, including the university faculty who are in charge of teacher preparation program design. Finally, the researcher intends to reward the participants by providing an equal opportunity to win one prize (25 $ card gift) for each class.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled. On the day of taking the survey, all participants must be 18 years or older. Having read the above and having had an opportunity to ask any questions please complete the questionnaire if you would like to participate in this research. **By completing the survey, you give your permission to be included in this study as a participant.** You may keep this form for future reference.

If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, 25 Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910. Thank you for your participation and collaboration in this research.

APPENDIX D

DESCRIPTIVE STATISTICS FOR ACADEMIC LEVELS

Descriptive Statistics (Academic Levels)

	Academic Level	*M*	*SD*	*N*
Student Learning	Freshman	2.6944	.44920	42
	Sophomore	2.6510	.55215	64
	Junior	2.7328	.55220	126
	Senior	2.7385	.63759	130
	Total	2.7159	.57276	362
Teaching Math	Freshman	3.4683	.42808	42
	Sophomore	3.5091	.49649	64
	Junior	3.4286	.56033	126
	Senior	3.5603	.57661	130
	Total	3.4947	.54272	362
Math Rated Affect	Freshman	3.4021	.88480	42
	Sophomore	3.3681	1.04623	64
	Junior	3.2654	1.04241	126
	Senior	3.1829	1.18455	130
	Total	3.2698	1.07892	362
Effectance Motivation	Freshman	3.3532	.68380	42
	Sophomore	3.2917	.77735	64
	Junior	3.2717	.78042	126
	Senior	3.2416	.94601	130
	Total	3.2739	.83091	362
Teacher Perception	Freshman	3.8968	.52182	42
	Sophomore	3.8281	.70521	64
	Junior	3.7706	.69540	126
	Senior	3.7449	.76845	130
	Total	3.7862	.70613	362
Usefulness of Math	Freshman	4.1317	.50992	42
	Sophomore	4.0959	.64831	64
	Junior	4.1803	.65742	126
	Senior	4.2701	.59153	130
	Total	4.1920	.61796	362

APPENDIX E

DESCRIPTIVE STATISTICS FOR ACADEMIC MAJOR

Descriptive Statistics (Academic Major)

	Academic Major	M	SD	N
Student Learning	Special Education	2.6777	.55266	121
	Elementary Education	2.7206	.58239	210
	Secondary Math Education	2.8333	.58531	31
	Total	2.7159	.57276	362
Teaching Math	Special Education	3.5689	.56792	121
	Elementary Education	3.3948	.50695	210
	Secondary Math Education	3.8817	.46586	31
	Total	3.4947	.54272	362
Math Rated Affect	Special Education	3.0129	1.12182	121
	Elementary Education	3.3249	1.06260	210
	Secondary Math Education	3.8996	.64044	31
	Total	3.2698	1.07892	362
Effectance Motivation	Special Education	3.1020	.79115	121
	Elementary Education	3.2407	.81381	210
	Secondary Math Education	4.1694	.48471	31
	Total	3.2739	.83091	362
Teacher Perception	Special Education	3.6391	.77798	121
	Elementary Education	3.8187	.64820	210
	Secondary Math Education	4.1398	.65418	31
	Total	3.7862	.70613	362
Usefulness of Math	Special Education	3.8872	.73199	121
	Elementary Education	4.2829	.47944	210
	Secondary Math Education	4.7661	.27840	31
	Total	4.1920	.61796	362

APPENDIX F

MULTIPLE COMPARISONS

Multiple Comparisons

Dependent Variable		(I) Academic Major	(J) Academic Major	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower	Upper
Student Learning	Tukey HSD	Special Education	Elementary Education	-.0429	.06538	.789	-.1968	.1109
			Secondary Math Education	-.1556	.11532	.369	-.4271	.1158
		Elementary Education	Special Education	.0429	.06538	.789	-.1109	.1968
			Secondary Math Education	-.1127	.11022	.563	-.3721	.1467
		Secondary Math Education	Special Education	.1556	.11532	.369	-.1158	.4271
			Elementary Education	.1127	.11022	.563	-.1467	.3721
	Scheffe	Special Education	Elementary Education	-.0429	.06538	.806	-.2037	.1178
			Secondary Math Education	-.1556	.11532	.403	-.4391	.1278
		Elementary Education	Special Education	.0429	.06538	.806	-.1178	.2037
			Secondary Math Education	-.1127	.11022	.593	-.3836	.1582
		Secondary Math Education	Special Education	.1556	.11532	.403	-.1278	.4391
			Elementary Education	.1127	.11022	.593	-.1582	.3836
	LSD	Special Education	Elementary Education	-.0429	.06538	.512	-.1715	.0856
			Secondary Math Education	-.1556	.11532	.178	-.3824	.0711
		Elementary Education	Special Education	.0429	.06538	.512	-.0856	.1715
			Secondary Math Education	-.1127	.11022	.307	-.3295	.1041
		Secondary Math Education	Special Education	.1556	.11532	.178	-.0711	.3824
			Elementary Education	.1127	.11022	.307	-.1041	.3295
Teaching Math	Tukey HSD	Special Education	Elementary Education	.1740*	.05991	.011	.0330	.3150
			Secondary Math Education	-.3128*	.10567	.009	-.5615	-.0642
		Elementary Education	Special Education	-.1740*	.05991	.011	-.3150	-.0330
			Secondary Math Education	-.4869*	.10100	.000	-.7246	-.2492

		Secondary Math Education	Special Education	.3128*	.10567	.009	.0642	.5615
			Elementary Education	.4869*	.10100	.000	.2492	.7246
	Scheffe	Special Education	Elementary Education	.1740*	.05991	.015	.0268	.3213
			Secondary Math Education	-.3128*	.10567	.013	-.5726	-.0531
		Elementary Education	Special Education	-.1740*	.05991	.015	-.3213	-.0268
			Secondary Math Education	-.4869*	.10100	.000	-.7351	-.2386
		Secondary Math Education	Special Education	.3128*	.10567	.013	.0531	.5726
			Elementary Education	.4869*	.10100	.000	.2386	.7351
	LSD	Special Education	Elementary Education	.1740*	.05991	.004	.0562	.2919
			Secondary Math Education	-.3128*	.10567	.003	-.5207	-.1050
		Elementary Education	Special Education	-.1740*	.05991	.004	-.2919	-.0562
			Secondary Math Education	-.4869*	.10100	.000	-.6855	-.2882
		Secondary Math Education	Special Education	.3128*	.10567	.003	.1050	.5207
			Elementary Education	.4869*	.10100	.000	.2882	.6855
Math Rated Affect	Tukey HSD	Special Education	Elementary Education	-.3120*	.12037	.027	-.5953	-.0287
			Secondary Math Education	-.8868*	.21230	.000	-.3864	-.3871
		Elementary Education	Special Education	.3120*	.12037	.027	.0287	.5953
			Secondary Math Education	-.5748*	.20292	.013	-.0523	-.0972
		Secondary Math Education	Special Education	.8868*	.21230	.000	.3871	1.3864
			Elementary Education	.5748*	.20292	.013	.0972	1.0523
	Scheffe	Special Education	Elementary Education	-.3120*	.12037	.036	-.6079	-.0161
			Secondary Math Education	-.8868*	.21230	.000	-.4086	-.3649
		Elementary Education	Special Education	.3120*	.12037	.036	.0161	.6079
			Secondary Math Education	-.5748*	.20292	.019	-.0735	-.0760
		Secondary Math Education	Special Education	.8868*	.21230	.000	.3649	1.4086
			Elementary Education	.5748*	.20292	.019	.0760	1.0735

	LSD	Special Education	Elementary Education	-.3120*	.12037	.010	-.5487	-.0753
			Secondary Math Education	-.8868*	.21230	.000	-.3043	-.4693
		Elementary Education	Special Education	.3120*	.12037	.010	.0753	.5487
			Secondary Math Education	-.5748*	.20292	.005	-.9738	-.1757
		Secondary Math Education	Special Education	.8868*	.21230	.000	.4693	1.3043
			Elementary Education	.5748*	.20292	.005	.1757	.9738
Effectance Motivation	Tukey HSD	Special Education	Elementary Education	-.1387	.08946	.269	-.3492	.0719
			Secondary Math Education	-1.0673*	.15779	.000	-.4387	-.6960
		Elementary Education	Special Education	.1387	.08946	.269	-.0719	.3492
			Secondary Math Education	-.9287*	.15082	.000	-.2836	-.5737
		Secondary Math Education	Special Education	1.0673*	.15779	.000	.6960	1.4387
			Elementary Education	.9287*	.15082	.000	.5737	1.2836
	Scheffe	Special Education	Elementary Education	-.1387	.08946	.302	-.3586	.0812
			Secondary Math Education	-1.0673*	.15779	.000	-.4552	-.6795
		Elementary Education	Special Education	.1387	.08946	.302	-.0812	.3586
			Secondary Math Education	-.9287*	.15082	.000	-.2994	-.5580
		Secondary Math Education	Special Education	1.0673*	.15779	.000	.6795	1.4552
			Elementary Education	.9287*	.15082	.000	.5580	1.2994
	LSD	Special Education	Elementary Education	-.1387	.08946	.122	-.3146	.0373
			Secondary Math Education	-1.0673*	.15779	.000	-.3777	-.7570
		Elementary Education	Special Education	.1387	.08946	.122	-.0373	.3146
			Secondary Math Education	-.9287*	.15082	.000	-.2253	-.6321
		Secondary Math Education	Special Education	1.0673*	.15779	.000	.7570	1.3777
			Elementary Education	.9287*	.15082	.000	.6321	1.2253
Teacher Perception	Tukey HSD	Special Education	Elementary Education	-.1796	.07929	.062	-.3662	.0070
			Secondary Math Education	-.5007*	.13986	.001	-.8298	-.1715

		Elementary Education	Special Education	.1796	.07929	.062	-.0070	.3662
			Secondary Math Education	-.3211*	.13368	.044	-.6357	-.0065
		Secondary Math Education	Special Education	.5007*	.13986	.001	.1715	.8298
			Elementary Education	.3211*	.13368	.044	.0065	.6357
	Scheffe	Special Education	Elementary Education	-.1796	.07929	.078	-.3745	.0153
			Secondary Math Education	-.5007*	.13986	.002	-.8444	-.1569
		Elementary Education	Special Education	.1796	.07929	.078	-.0153	.3745
			Secondary Math Education	-.3211	.13368	.057	-.6496	.0075
		Secondary Math Education	Special Education	.5007*	.13986	.002	.1569	.8444
			Elementary Education	.3211	.13368	.057	-.0075	.6496
	LSD	Special Education	Elementary Education	-.1796*	.07929	.024	-.3356	-.0237
			Secondary Math Education	-.5007*	.13986	.000	-.7757	-.2256
		Elementary Education	Special Education	.1796*	.07929	.024	.0237	.3356
			Secondary Math Education	-.3211*	.13368	.017	-.5839	-.0582
		Secondary Math Education	Special Education	.5007*	.13986	.000	.2256	.7757
			Elementary Education	.3211*	.13368	.017	.0582	.5839
Usefulness of Math	Tukey HSD	Special Education	Elementary Education	-.3957*	.06450	.000	-.5475	-.2439
			Secondary Math Education	-.8789*	.11377	.000	-.1467	-.6112
		Elementary Education	Special Education	.3957*	.06450	.000	.2439	.5475
			Secondary Math Education	-.4833*	.10874	.000	-.7392	-.2273
		Secondary Math Education	Special Education	.8789*	.11377	.000	.6112	1.1467
			Elementary Education	.4833*	.10874	.000	.2273	.7392
	Scheffe	Special Education	Elementary Education	-.3957*	.06450	.000	-.5542	-.2371
			Secondary Math Education	-.8789*	.11377	.000	-.1586	-.5993
		Elementary Education	Special Education	.3957*	.06450	.000	.2371	.5542
			Secondary Math Education	-.4833*	.10874	.000	-.7505	-.2160

	Secondary Math Education	Special Education	.8789*	.11377	.000	.5993	1.1586
		Elementary Education	.4833*	.10874	.000	.2160	.7505
LSD	Special Education	Elementary Education	-.3957*	.06450	.000	-.5225	-.2688
		Secondary Math Education	-.8789*	.11377	.000	-.1027	-.6552
	Elementary Education	Special Education	.3957*	.06450	.000	.2688	.5225
		Secondary Math Education	-.4833*	.10874	.000	-.6971	-.2694
	Secondary Math Education	Special Education	.8789*	.11377	.000	.6552	1.1027
		Elementary Education	.4833*	.10874	.000	.2694	.6971

APPENDIX G

MULTIPLE LINEAR REGRESSION MODELS FOR RESEARCH QUESTION 4

Multiple Linear Regression Models

Variables Entered/ Removed[a]

Model	Variables Entered	Method
1	Math Rated Affect	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Student Learning

Model Summary

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	d	df	Sig. F Change
1	.17	.031	.028	.56454	.031	11.586	1	3	.001

a. Predictors: (Constant), Math Rated Affect

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.693	1	3.693	11.586	.001[b]
	Residual	114.734	360	.319		
	Total	118.427	361			

a. Dependent Variable: Student Learning

b. Predictors: (Constant), Math Rated Affect

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.409	.095		25.413	.000		
	Math Rated Affect	.094	.028	.177	3.404	.001	1.000	1.000

a. Dependent Variable: Student Learning

Excluded Variables[a]

Model		Beta In	t	Sig	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Effectance Motivation	.046[b]	.550	.58	.029	.389	2.57	.389
	Teacher Perception	-.125[b]	-1.957	.05	-.103	.650	1.53	.650
	Usefulness of Math	-.004[b]	-.080	.93	-.004	.883	1.13	.883

a. Dependent Variable: Student Learning

b. Predictors in the Model: (Constant), Math Rated Affect

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Math Rated Affect
1	1	1.950	1.000	.03	.03
	2	.050	6.230	.97	.97

a. Dependent Variable: Student Learning

Correlations

		Student Learning	Math Rated Affect	Effectance Motivation	Teacher Perception	Usefulness of Math
Pearson Correlation	Student Learning	1.000	.177	.156	.023	.057
	Math Rated Affect	.177	1.000	.782	.591	.343
	Effectance Motivation	.156	.782	1.000	.508	.475
	Teacher Perception	.023	.591	.508	1.000	.339
	Usefulness of Math	.057	.343	.475	.339	1.000
Sig. (1-tailed)	Student Learning	.	.000	.001	.332	.141
	Math Rated Affect	.000	.	.000	.000	.000
	Effectance Motivation	.001	.000	.	.000	.000
	Teacher Perception	.332	.000	.000	.	.000
	Usefulness of Math	.141	.000	.000	.000	.
N	Student Learning	362	362	362	362	362
	Math Rated Affect	362	362	362	362	362
	Effectance Motivation	362	362	362	362	362
	Teacher Perception	362	362	362	362	362
	Usefulness of Math	362	362	362	362	362

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Usefulness, Teacher Perception, Effecatnce Motivation, Math Rated Affect[b]		Enter
2		Usefulness	Backward (criterion: Probability of F-to-remove >= .100).
3		Motivation	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: Learning
b. All requested variables entered.

Model Summary

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.207[a]	.043	.032	.56348	.043	3.996	4	35	.003
2	.207	.043	.035	.56270	.000	.001	1	35	.980
3	.203[c]	.041	.036	.56234	-.001	.539	1	35	.463

a. Predictors: (Constant), Usefulness, Teacher Per, Motivation, Math Affect
b. Predictors: (Constant), Teacher Per, Motivation, Math Affect
c. Predictors: (Constant), Teacher Per, Math Affect

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.075	4	1.269	3.996	.003[b]
	Residual	113.352	357	.318		
	Total	118.427	361			
2	Regression	5.075	3	1.692	5.342	.001[c]
	Residual	113.353	358	.317		
	Total	118.427	361			
3	Regression	4.904	2	2.452	7.754	.001[d]
	Residual	113.523	359	.316		
	Total	118.427	361			

a. Dependent Variable: Student Learning
b. Predictors: (Constant), Usefulness of Math, Teacher Per, Motivation, Math Affect
c. Predictors: (Constant), Teacher Per, Motivation, Math Affect
d. Predictors: (Constant), Teacher Per, Math Affect

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.616	.228		11.474	.000		
	Math Affect	.109	.048	.206	2.296	.022	.334	2.99
	Motivation	.042	.061	.060	.680	.497	.340	2.94
	Teacher Per	-.105	.053	-.130	-1.991	.047	.629	1.59
	Usefulness	.001	.055	.001	.025	.980	.753	1.32
2	(Constant)	2.620	.173		15.107	.000		
	Math Affect	.109	.047	.205	2.310	.021	.338	2.95
	Motivation	.042	.057	.061	.734	.463	.385	2.59
	Teacher Per	-.105	.052	-.130	-2.015	.045	.645	1.55
3	(Constant)	2.666	.162		16.506	.000		
	Math Affect	.133	.034	.251	3.913	.000	.650	1.53
	Teacher Per	-.102	.052	-.125	-1.957	.051	.650	1.53

a. Dependent Variable: Learning

Collinearity Diagnostics[a]

				Variance Proportions				
Model	Dimension	Eigenvalue	Condition Index	(Constant)	Math Affect	Motivation	Teacher Perception	Usefulness
1	1	4.892	1.000	.00	.00	.00	.00	.
	2	.066	8.629	.06	.25	.03	.01	.
	3	.021	15.369	.00	.07	.33	.51	.
	4	.013	19.763	.16	.68	.52	.43	.
	5	.010	22.675	.77	.01	.12	.06	.
2	1	3.913	1.000	.00	.00	.00	.00	
	2	.056	8.362	.21	.26	.03	.03	
	3	.019	14.525	.07	.20	.63	.40	
	4	.012	17.893	.72	.54	.34	.56	
3	1	2.934	1.000	.00	.01		.00	
	2	.052	7.482	.22	.75		.02	
	3	.014	14.535	.78	.24		.98	

a. Dependent Variable: Learning

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
2	Usefulness	.001[b]	.02	.98	.001	.753	1.32	.334
3	Usefulness	.015[c]	.27	.78	.015	.854	1.17	.627
	Motivation	.061[c]	.73	.46	.039	.385	2.59	.338

a. Dependent Variable: Learning

b. Predictors in the Model: (Constant), Teacher Per, Motivation, Math Affect

c. Predictors in the Model: (Constant), Teacher Per, Math Affect

Correlations

		Learning	Math Affect	Motivation	Teacher Perception	Usefulness Of Math
Pearson Correlation	Learning	1.000	.177	.156	.023	.057
	Math Affect	.177	1.000	.782	.591	.343
	Motivation	.156	.782	1.000	.508	.475
	Teacher Per	.023	.591	.508	1.000	.339
	Usefulness	.057	.343	.475	.339	1.000
Sig. (1-tailed)	Learning	.	.000	.001	.332	.141
	Math Affect	.000	.	.000	.000	.000
	Motivation	.001	.000	.	.000	.000
	Teacher Per	.332	.000	.000	.	.000
	Usefulness	.141	.000	.000	.000	.
N	Learning	362	362	362	362	362
	Math Affect	362	362	362	362	362
	Motivation	362	362	362	362	362
	Teacher Per	362	362	362	362	362
	Usefulness	362	362	362	362	362

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Math Affect	.	Forward (Criterion: Probability-of-F-to-enter <= .050)

a. Dependent Variable: Learning

Model Summary

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	*F* Change	df1	df2	Sig. F Change
1	.177[a]	.031	.028	.56454	.031	11.586	1	360	.001

a. Predictors: (Constant), Math Affect

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.693	1	3.693	11.586	.001[b]
	Residual	114.734	360	.319		
	Total	118.427	361			

a. Dependent Variable: Learning
b. Predictors: (Constant), Math Affect

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.409	.095		25.413	.000		
	Math Affect	.094	.028	.177	3.404	.001	1.000	1.000

a. Dependent Variable: Learning

Excluded Variables[a]

Model		Beta In	t	Sig	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Motivation	.046[b]	.550	.58	.029	.389	2.57	.389
	Teacher Perception	-.125[b]	-1.957	.05	-.103	.650	1.53	.650
	Usefulness	-.004[b]	-.080	.93	-.004	.883	1.13	.883

a. Dependent Variable: Learning
b. Predictors in the Model: (Constant), Math Affect

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Math Affect
1	1	1.950	1.000	.03	.03
	2	.050	6.230	.97	.97

a. Dependent Variable: Learning

APPENDIX H

MULTIPLE LINEAR REGRESSION MODELS FOR RESEARCH QUESTION 5

Multiple Linear Regression Models for RQ5

Correlation

		Teaching Math	Math Affect	Motivation	Teacher Perception	Usefulness
Pearson Correlation	Teaching Math	1.000	.204	.289	.082	.142
	Math Affect	.204	1.000	.782	.591	.343
	Motivation	.289	.782	1.000	.508	.475
	Teacher Per	.082	.591	.508	1.000	.339
	Usefulness	.142	.343	.475	.339	1.000
Sig. (1-tailed)	Teaching Math	.	.000	.000	.059	.003
	Math Affect	.000	.	.000	.000	.000
	Motivation	.000	.000	.	.000	.000
	Teacher Per	.059	.000	.000	.	.000
	Usefulness	.003	.000	.000	.000	.
N	Teaching Math	362	362	362	362	362
	Math Affect	362	362	362	362	362
	Motivation	362	362	362	362	362
	Teacher Per	362	362	362	362	362
	Usefulness	362	362	362	362	362

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Usefulness, Teacher Per, Motivation, Math Affect[b]	.	Enter
2	.	Math Affect	Backward (criterion: Probability of F-to-remove >= .100).
3	.	Usefulness	Backward (criterion: Probability of F-to-remove >= .100).
4	.	Teacher Per	Backward (criterion: Probability of F-to-remove >= .100).

a. Dependent Variable: Teaching Math
b. All requested variables entered

Model Summary

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df 1	df2	Sig. F Change
1	.299[a]	.089	.079	.52081	.089	8.751	4	35	.000
2	.299	.089	.082	.52010	.000	.016	1	35	.898
3	.298[c]	.089	.084	.51943	.000	.085	1	35	.771
4	.289	.083	.081	.52031	-.006	2.217	1	35	.137

a. Predictors: (Constant), Usefulness, Teacher Per, Motivation, Math Affect
b. Predictors: (Constant), Usefulness, Teacher Per, Motivation
c. Predictors: (Constant), Teacher Per, Motivation
d. Predictors: (Constant), Motivation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.495	4	2.374	8.751	.000[b]
	Residual	96.835	357	.271		
	Total	106.330	361			
2	Regression	9.491	3	3.164	11.695	.000[c]
	Residual	96.839	358	.271		
	Total	106.330	361			
3	Regression	9.468	2	4.734	17.545	.000[d]
	Residual	96.862	359	.270		
	Total	106.330	361			
4	Regression	8.870	1	8.870	32.762	.000[e]
	Residual	97.461	360	.271		
	Total	106.330	361			

a. Dependent Variable: Teaching Math
b. Predictors: (Constant), Usefulness, Teacher Per, Motivation, Math Affect
c. Predictors: (Constant), Usefulness, Teacher Per, Motivation
d. Predictors: (Constant), Teacher Per, Motivation
e. Predictors: (Constant), Motivation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.991	.211		14.196	.000		
	MathAffect	-.006	.044	-.011	-.128	.898	.334	2.99
	Motivation	.218	.057	.334	3.852	.000	.340	2.94
	TeacherPer	-.066	.049	-.086	-1.355	.176	.629	1.59
	Usefulness	.014	.051	.016	.275	.784	.753	1.32
2	(Constant)	2.995	.208		14.369	.000		
	Motivation	.213	.041	.326	5.166	.000	.638	1.56
	TeacherPer	-.069	.045	-.089	-1.512	.131	.729	1.37
	Usefulness	.015	.051	.017	.291	.771	.761	1.31
3	(Constant)	3.036	.154		19.713	.000		
	Motivation	.218	.038	.333	5.694	.000	.741	1.34
	TeacherPer	-.067	.045	-.087	-1.489	.137	.741	1.34
4	(Constant)	2.877	.111		25.848	.000		
	Motivation	.189	.033	.289	5.724	.000	1.000	1.00

a. Dependent Variable: Teaching Math

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions: (Constant)	Math Affect	Motivation	Teacher Per	Usefulness of Math
1	1	4.892	1.000	.00	.00	.00	.00	.00
	2	.066	8.629	.06	.25	.03	.01	.04
	3	.021	15.369	.00	.07	.33	.51	.10
	4	.013	19.763	.16	.68	.52	.43	.06
	5	.010	22.675	.77	.01	.12	.06	.81
2	1	3.938	1.000	.00		.00	.00	.00
	2	.034	10.830	.13		.78	.00	.03
	3	.019	14.311	.03		.07	.90	.19
	4	.010	20.322	.84		.14	.09	.78
3	1	2.952	1.000	.00		.01	.00	
	2	.032	9.629	.32		.88	.04	
	3	.016	13.600	.68		.11	.96	
4	1	1.969	1.000	.02		.02		
	2	.031	8.016	.98		.98		

a. Dependent Variable: Teaching Math

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics: Tolerance	VIF	Minimum Tolerance
2	Math Affect	-.011[b]	-.128	.898	-.007	.334	2.993	.334
3	Math Affect	-.014[c]	-.159	.874	-.008	.338	2.959	.338
	Usefulness	.017[c]	.291	.771	.015	.761	1.313	.638
4	Math Affect	-.055[d]	-.684	.494	-.036	.389	2.573	.389
	Usefulness	.006[d]	.097	.923	.005	.774	1.292	.774
	Teacher Per	-.087[d]	-1.489	.137	-.078	.741	1.349	.741

a. Dependent Variable: Teaching Math
b. Predictors in the Model: (Constant), Usefulness, Teacher Per, Motivation
c. Predictors in the Model: (Constant), Teacher Per, Motivation
d. Predictors in the Model: (Constant), Motivation

Correlations

		Teaching	Math Affect	Motivation	Teacher Per	Usefulness
Pearson Correlation	Teaching	1.000	.204	.289	.082	.142
	Math Affect	.204	1.000	.782	.591	.343
	Motivation	.289	.782	1.000	.508	.475
	Teacher Per	.082	.591	.508	1.000	.339
	Usefulness	.142	.343	.475	.339	1.000
Sig. (1-tailed)	Teaching	.	.000	.000	.059	.003
	Math Affect	.000	.	.000	.000	.000
	Motivation	.000	.000	.	.000	.000
	Teacher Per	.059	.000	.000	.	.000
	Usefulness	.003	.000	.000	.000	.
N	Teaching	362	362	362	362	362
	Math Affect	362	362	362	362	362
	Motivation	362	362	362	362	362
	Teacher Per	362	362	362	362	362
	Usefulness	362	362	362	362	362

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Motivation	.	Forward (Criterion: Probability-of-F-to-enter <= .050)

a. Dependent Variable: Teaching Math

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df	Sig. F Change
1	.289	.083	.081	.52031	.083	32.762	1	3	0.000

a. Predictors: (Constant), Motivation

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8.870	1	8.870	32.762	.000[b]
	Residual	97.461	360	.271		
	Total	106.330	361			

a. Dependent Variable: Teaching Math
b. Predictors: (Constant), Motivation

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.877	.111		25.848	.000		
	Motivation	.189	.033	.289	5.724	.000	1.000	1.000

a. Dependent Variable: Teaching Math

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Math Affect	-.055[b]	-.684	.49	-.036	.389	2.573	.389
	Teacher Perception	-.087[b]	-1.489	.13	-.078	.741	1.349	.741
	Usefulness	.006[b]	.097	.92	.005	.774	1.292	.774

a. Dependent Variable: Teaching Math
b. Predictors in the Model: (Constant), Motivation

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Motivation
1	1	1.969	1.000	.02	.02
	2	.031	8.016	.98	.98

a. Dependent Variable: Teaching Math