THE RELATIONSHIP BETWEEN ELEMENTARY TEACHERS' SELF-EFFICACY FOR TEACHING MATHEMATICS AND THEIR MATHEMATICAL KNOWLEDGE FOR TEACHING

by

Meagan McKinney

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Meagan McKinney

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The following individuals read and discussed the thesis submitted by student Meagan McKinney, and they evaluated her presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

Michele Carney, Ph.D.	Chair, Supervisory Committee
Philip P. Kelly, Ph.D.	Member, Supervisory Committee
Laurie Cavey, Ph.D.	Member, Supervisory Committee

The final reading approval of the thesis was granted by Michele Carney, Ph.D., Chair of the Supervisory Committee. The thesis was approved for the Graduate College by John R. Pelton, Ph.D., Dean of the Graduate College.

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ABSTRACT

This study examined the relationship between elementary teachers' mathematical knowledge for teaching (MKT) and their self-efficacy for teaching mathematics. Self-efficacy and MKT are of high importance with implications in regards to quality of instruction and the Common Core State Standards for mathematics. Using the Content Knowledge for Teaching Mathematics (CKT-M) instrument, data for this study were collected from thirty-five elementary school teachers participating in the Improving Teachers' Monitoring of Learning Grant at the time. The data were concerned with these teachers' self-efficacy with the pedagogy and content of mathematics using the Self-Efficacy for Teaching Mathematics Instrument (SETMI). Qualitative data were collected pertaining to teachers' perceptions of the positive influences and challenges of implementing the Common Core State Standards into their classroom.

A correlational analysis was run with the data collected from the survey to test for a relationship between the two self-efficacy constructs and the MKT. The results indicated no statistically significant relationship between either of the two self-efficacy constructs and participants' MKT. The qualitative data responses revealed the themes of training and support as positive influences, while curriculum and time demands were seen as the major challenges. Further research should be conducted to continue examining the relationship between self-efficacy and MKT using a larger, random sample to help gain a more true representation of the larger population.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

SETMI	Self-Efficacy for Teaching Mathematics Instrument
MKT	Mathematical Knowledge for Teaching
CCSS	Common Core State Standards

CHAPTER ONE: INTRODUCTION

Statement of Problem

Mathematics education is going through reform with the introduction of the Common Core State Standards (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These new standards are more rigorous than previous state standards and impose a higher demand on teachers, in terms of both content knowledge and pedagogical skills (Dacey & Polly, 2012). My study examines whether mathematical knowledge for teaching (MKT) is related to elementary teacher self-efficacy, specifically their self-efficacy for mathematics pedagogy and their self-efficacy for teaching mathematics content. This is important because new standards are only a set of guidelines that help teachers be aware of the skills and content that is expected to be learned at each grade level. It is not an outlined curriculum. How the standards are implemented in the classroom is a determining factor for the effectiveness of this reform in mathematics education. Teachers' confidence with content may influence their execution of the standards. The purpose of my study was to examine the relationship between the elementary teachers' mathematical knowledge for teaching and their self-efficacy in teaching the mathematical content to their students.

In this thesis, I examined the broad topic of self-efficacy in regards to elementary school teachers and mathematics. My interest was sparked after multiple discussions with pre-service teachers who explained their feelings about math, often discussing their discomfort with mathematics content. These discussions led me to examine the topic of self-efficacy, more specifically, self-efficacy in regards to teaching. Alongside self-efficacy, I began researching the MKT that was required of elementary teachers. I started to wonder if the amount of MKT that a teacher possessed had a relationship with their self-efficacy in regards to math, particularly in the teaching of mathematics.

For this study, two different instruments were used. To collect data on teachers' mathematical knowledge for teaching, I used the Content Knowledge for Teaching Mathematics [CKT-M] inventory created by The Learning Mathematics for Teaching project at the University of Michigan (2004). The CKT-M consisted of multiple choice questions addressing two different domains: knowledge of content used in grades K-5 and the combined knowledge of content and students (Hill, Schilling, & Ball, 2004; Ball, Thames, & Phelps, 2008). Results from the CKT-M measured teachers' common content knowledge as well as the ability to recognize the unique skills and capabilities teachers might need to draw upon while teaching (Hill, Rowan, & Ball, 2005). To measure teachers' self-efficacy, I chose to use the Self-Efficacy for Teaching Mathematics Instrument (McGee, 2012). This instrument includes Likert-scale questions that assess a teacher's self-efficacy for mathematics pedagogy and teaching mathematics content.

Research Questions

The following research questions guided the study. The wording for these research questions was developed using the two different constructs from the data collection instruments.

1. What is the relationship between mathematical knowledge for teaching and self-efficacy for mathematics pedagogy?

2. What is the relationship between mathematical knowledge for teaching and self-efficacy for teaching mathematics content?

A third research question pertained to the qualitative data. This question focused more exclusively on factors relating to the implementation of the CCSS for mathematics that teachers believed had an impact, either positive or negative, on their implementation of the standards.

3. What factors contribute to successfully implementing the Common Core State Standards for Mathematics, as well as the factors that hinder the implementation of those same standards?

Key Terms

Common Core State Standards: a set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade. The standards were created to ensure that all students graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Self-Efficacy: beliefs about one's ability to successfully perform a task (Bandura, 1993).

Content Knowledge: the amount and organization of knowledge per se in the mind of the teacher (Shulman, 1986, p. 9).

Mathematical Knowledge for Teaching: the mathematical knowledge needed to carry out the work of teaching mathematics (Ball et al., 2008).

Teaching Efficacy: a teacher’s judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated (Tschannen-Moran & Hoy, 2001, p. 783).

Personal Mathematics Teaching Efficacy: teachers’ own beliefs in their skills or abilities in being an effective teacher (Swars & Dooley, 2010).

Teaching Outcome Expectancy: teacher’s belief on effective teaching and its connection to student learning (Swars & Dooley, 2010).

CHAPTER TWO: REVIEW OF LITERATURE

Introduction

The introduction of the No Child Left Behind Act in 2001 introduced the concept of having teachers in schools who were considered to be “highly qualified” (Smith & Gorard, 2007). For teachers to be thought of as highly qualified, they must have a bachelor's degree, certification in the state in which they teach, and proof of knowledge in the subject content that they teach, normally achieved by passing content-specific certification tests. The requirement of being able to demonstrate competency in the subject matter they teach reinforces research conducted by Ball et al., (2008) on the topic of what content knowledge teachers need to have, especially at the elementary level where they are expected to teach all subjects.

MKT of a “highly qualified” teacher goes beyond the basic facts and procedures and is far different from what is needed in other professions (Hill & Ball, 2009). According to Ball et al. (2008), “high-quality instruction requires a sophisticated, professional knowledge that goes beyond simple rules” (p. 391). Teachers must not only have knowledge about the subject content, they also must have a deep conceptual understanding to break the concepts down and have the ability to think from the students’ perspective when students are learning mathematical ideas for the first time. Teachers must take into consideration the skills and knowledge needed to develop an understanding of a new idea (Ball et al., 2008). With this renewed focus on what content knowledge teachers really need to know, the notion of mathematical knowledge for teaching has become the focus of many recent studies (Ball, Hill, & Bass, 2005; Hill & Ball, 2009; Hill et al., 2005; Hill et al., 2004).

MKT is an important concept due to its implications for quality mathematical instruction. According to Ball et al. (2005), mathematics instruction quality depends heavily on the content knowledge the teacher holds. Now with the introduction of the more rigorous mathematics standards within the Common Core State Standards, the MKT required at the elementary level has increased (Hull, Balka, & Miles, 2013). Effectively implementing these standards requires teachers to not only engage themselves and their students in higher level thinking to learn the new mathematics content but also requires some revising of pedagogical skills to help students develop the desired deeper conceptual understanding (Sawchuk, 2012). This demand not only puts a new emphasis on the mathematical knowledge for teaching needed by elementary teachers but also on the teachers' beliefs of their capability to be able to address these new standards. Do teachers feel confident in their knowledge of the more rigorous mathematical content as well as the pedagogical skills needed to teach it effectively? To look deeper into this idea, a research question was developed to act as a guide while investigating: "How is elementary teachers' mathematical knowledge for teaching related to their self-efficacy in teaching the mathematical content to students?"

Common Core State Standards

The most recent wave of reform in mathematics education began with the creation of the Common Core State Standards (CCSS). The CCSS are different from past educational standards because they were initiated and developed under the leadership of state governments aiming to improve content instruction (Schmidt & Burroughs, 2013). These standards were formed through collaboration among the National Governors Association and the Council of Chief State School Officers with input provided by teachers, parents, school administrators, and experts in appropriate fields (Main, 2010). The CCSS are a set of national standards, for not only mathematics but also English Language Arts, which are intended to provide students with the knowledge and skills necessary to be college and career ready when they graduate from high school (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

The most notable change that the CCSS brings to mathematics in the classroom is the reduction in the number of standards that teachers are expected to address. The CCSS for mathematics has a two part structure that includes Standards for Mathematical Practice and Standards for Mathematical Content (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The Standards for Mathematical Practice are eight overall standards for all grades (K-12) that pertain to how students are to be engaged in mathematics. This engagement and application practice is to help students develop a conceptual understanding of mathematical concepts, operations, and relations along with fluency in carrying out mathematical procedures (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). The Standards for Mathematical Content include more standards than the Standards for Mathematical Practice, but build on each other from grade to grade (Burns, 2013). These standards are considered to be more rigorous than most states' previous mathematics standards, requiring teachers to focus more on teaching mastery of the concepts instead of a focus on procedures and skills. The higher levels of thinking, reading, and overall depth of knowledge that are required make these standards more rigorous (Hull et al., 2013).

A survey of 403 middle school students (Brown, 2013) found that many of the teachers indicated that they were familiar with the standards but did not feel prepared to teach them. They believed that the CCSS-M were more rigorous than their current state math standards. These standards also differ from other types of mathematics education revision and reform because of their focus on how students form their understanding when learning mathematical concepts (Ellis & Berry, 2005). To meet the standards, teachers are required to challenge their students to explore, ask questions, take chances, and not be afraid to make errors (Burns, 2013). This is done through teaching based on conceptual understanding, reasoning, and problem solving.

More rigorous standards mean increased expectations of teachers, especially at the elementary level. Teachers must begin to think differently about mathematics. The overall content is more complex. There is also the shift in the way that content is being taught. There is much more of a focus on flexibility in thinking and overall conceptual understanding versus completing a procedure and knowing the basic skill (Ellis & Berry, 2005; Batista, 1994; Dacey & Polly, 2012). Students learn the underlying reasoning behind what they do in order to use the strategies in multiple contexts. This type of mathematics education is very different from what many current teachers experienced when they were in school. These changes in thinking and instruction will require time, energy, and commitment from the teachers to maximize the benefits of the new CCSS-M (Ellis & Berry, 2005).

The standards that are included focus on what the creators thought were the most important topics to teach at each grade level (Sawchuk, 2012). This allows teachers more time to provide students with ample opportunities to build and practice the mathematical skills and deepen their understanding of the various mathematics concepts. Teachers must function at a higher cognitive level to help engage their students in higher order thinking. This higher order thinking includes an emphasis on helping students develop an understanding of both the logical and structural concepts that are the foundation of mathematics (Sawchuk, 2012). All these changes require pedagogical shifts in the way teachers address teaching mathematics along with increasing their self-efficacy and MKT.

Self-Efficacy

The idea of self-efficacy stems from Bandura's social cognitive theory. Bandura (1993) defines self-efficacy as self-referent phenomena that influences the selection and creation of his or her environment. Self-efficacy is a mechanism of agency that is two-dimensional. The first dimension is an individual's belief in his or her ability to successfully perform a behavior. The second dimension is an individual's belief that the performance of the behavior will have a desirable outcome (Powell-Moman & Brown-Schild, 2011). Self-efficacy can be classified as either being high self-efficacy or low self-efficacy. Bandura (1993) found that to have high self-efficacy meant that one was confident in that particular area, whatever it may be. However, to be effective one must not only have high self-efficacy about the content, but also high self-efficacy on how to use the tools and skills to apply the knowledge of the content.

Self-efficacy can be examined more specifically in regards to teachers and their teaching or instructional efficacy. Tschannen-Moran and Hoy (2001) defined teaching efficacy as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (p. 783). Swars and Dooley (2010) defined teaching efficacy as having two parts. The first part, personal teaching efficacy, is teachers' beliefs in their skills or abilities to be effective teachers. When related to mathematics, it can be considered as a teacher's personal mathematics teaching efficacy, looking at teachers' beliefs in their skills or abilities to be effective teachers of mathematics (Briley, 2012). The second part of teaching efficacy is teaching outcome expectancy. This looks more specifically at a teacher's belief in effective teaching and its connection to student learning (Swars & Dooley, 2010).

Bandura (1993) believed that self-efficacy was influenced by the number of mastery experiences a person has, vicarious experiences of the effects produced by the actions of others, social persuasions, and physiological factors such as stress, anxiety, arousal, and fatigue. Relating this back to a teacher's personal mathematics teaching efficacy, it is a teacher's own personal self-efficacy with mathematics content, their own beliefs about mathematics, and their past experiences with the content that influences their personal mathematics teaching efficacy (Briley, 2012). A study conducted by Briley (2012) focused on elementary pre-service teachers and the relationship between mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs. Pre-service teachers who were enrolled in the Mathematics for the Elementary School Teacher class were the selected sample for this study. Participants completed three different surveys pertaining to the following categories: mathematics teaching efficacy, mathematics self-efficacy, and conceptions of mathematics to measure mathematical beliefs. Results from the study found that mathematical beliefs and mathematical self-efficacy were statistically significant predictors of mathematical teaching efficacy.

Overall self-efficacy beliefs can influence people in four ways. These beliefs influence people through how they think, how they feel, how they choose to motivate themselves, and how they behave (Bandura, 1993). Of these four influences, a variety of research has been done looking specifically at the relationship between motivation and self-efficacy. According to Bandura (1993), people are motivated by their views of what they think they can or cannot do. Self-efficacy directly affects the goals that people set, the effort and perseverance that is put towards accomplishing these goals, and the resilience to fight back for goals that aren't met. People who have a higher self-efficacy tend to set higher goals for themselves because they believe that they have the capability to accomplish these loftier goals. When relating these ideas to teachers, teachers who have higher self-efficacy tend to exude the following characteristics: work longer with students, are able to more easily recognize student errors, and are more likely to adapt and attempt new teaching methods in order to better assist their students (Swackhamer, Koellner, Basile, & Kimbrough, 2009).

Self-efficacy, or teaching efficacy, has the power to influence factors that affect others around the teacher. Holzberger, Philipp, and Kunter (2013) found that teaching efficacy had an effect on teacher performance and instructional quality in the classroom. In a study, Holzberger et al. examined how self-efficacy beliefs affected instructional quality, rated by both the teacher and their students. Data was collected at the end of 9th grade and at the end of 10th grade. After analysis of the data, the researchers found there to be “significant positive correlations between teachers’ self-efficacy beliefs and both the teacher and the students’ ratings of instruction quality” (Holzberger et al., 2013, p. 779). They also found that the teacher’s self-efficacy fluctuated throughout the year depending on successes and failures with the content they experienced. Teaching efficacy also affects the students in the classroom. Teaching efficacy has been linked to student achievement outcomes, student motivation, and a student’s own self-efficacy (Tschannen-Moran & Hoy, 2001).

The idea of how the strength of teaching efficacy influences performance of teachers and their students is the most common focus for researchers studying teaching efficacy. With this focus, teaching efficacy is typically seen as being either high or low in regards to their confidence in their ability to influence student outcomes. Wheatley (2002) took a different approach in his research instead focusing on the potential benefits of what he called “teacher efficacy doubts” (p. 8). He examined teacher efficacy beliefs in regards to their ability to learn rather than their performance. Teachers having these teacher efficacy doubts can in fact be beneficial to educational reforms that are put into action, such as the CCSS. When looking at teacher efficacy specifically regarding reform and efficacy doubts such as outcome expectancy, personal teaching efficacy, and efficacy expectancies, Wheatley (2002) found there to be six potential benefits for these doubts: prompt instability and change, self-reflection, motivation to learn, strategies for handling diversity, productive collaboration, and willingness to try progressive teaching techniques. The implications of this research led to the idea of whether or not teachers’ having lower self-efficacy is a positive or negative finding in regards to their ability to assess their own need for learning and potential growth. This can be an important piece to teachers' receptiveness of instruction and information given during professional development, other continuing education opportunities, and their perception of their knowledge for teaching.

Teaching efficacy can also be related to how comfortable a teacher is with the content being taught (Nadelson, Seifert, Moll, & Coats, 2012; Powell-Moman & Brown-Schild, 2011). Nadelson et al. (2012) found that when teachers were uncomfortable with the topic or subject they were teaching they tended to avoid teaching the topic beyond the superficial layer or even avoided teaching the topic all together. However, because self-efficacy is related to the content being taught, teachers can have different teaching efficacy for the different subjects. This difference in teaching efficacy based off of specific content areas can be viewed in a positive light. According to Wheatley (2002), this lower teaching efficacy, or teaching efficacy doubt, in a specific content area can benefit teachers in their desire and openness to continue to learn and improve their knowledge and pedagogical skills. Teachers who are more comfortable with topics, such as reading and writing, will have higher self-efficacy in those subject areas compared to other subjects where they may have less confidence.

Knowledge for Teaching

Elementary teachers are expected to have the comprehensive knowledge to be able to teach all subjects throughout the day to their students. Not only do they need to know the content but they must be able to make it understandable for their students. The question has been raised about how much knowledge teachers need to have in each content area. Most teachers, it can be presumed, come into their teaching profession with some expertise in the content they are teaching. According to Shulman (1986), teachers must have what he referred to as content knowledge. Put simply, content knowledge is "the amount and organization of knowledge per se in the mind of the teacher" (Shulman, 1986, p. 9). This content knowledge goes beyond the understanding of the concepts and facts and requires teachers to have a familiarity with the structures of the subject matter. This involves teachers knowing the basic definition or idea of the concept. They must also be able to explain to students why the procedure taught is correct, why the content is worth knowing, and how it is related to other concepts and procedures within the mathematics subject area (Shulman, 1986).

Teachers must know the content as well as how to teach it and make it available for their students; they must be able to unpack the information. Shulman (1986) referred to this as pedagogical content knowledge. This is one of the most important forms of knowledge for a teacher to have. It is what gives teachers the ability to bridge the gap between students' informal ways of thinking and understanding a concept and formal ways of presenting these concepts. Pedagogical content knowledge pertains to having the subject matter knowledge for teaching. The components of pedagogical content knowledge include knowing the best and more powerful representations, analogies, illustrations, demonstrations, examples, and explanations (Shulman, 1986). It also includes being able to clarify ideas for students and having the understanding of what makes certain topics easy or difficult. This helps in the clarification of preconceptions or misconceptions during instruction. Another type of content knowledge that goes along with pedagogical content knowledge is curricular knowledge (Shulman, 1986). Curricular knowledge is having the knowledge and familiarity with the curriculum to be able to alter materials to better fit students' needs (Shulman, 1986). This includes relating the content across multiple subjects as well as relating it to information that has been taught previously or will be taught in the future.

This question of how much content knowledge elementary teachers need, especially in terms of mathematics, has been the topic of many studies (Ball et al., 2005; Ball et al., 2008; Hill & Ball, 2009; Hill et al., 2005; Hill et al., 2004). Ball et al. (2008) used Shulman's (1986) ideas of content knowledge and pedagogical content knowledge to develop what they call mathematical knowledge for teaching. Mathematical knowledge for teaching refers to "the mathematical knowledge needed to carry out the work of teaching mathematics" (Ball et al., 2008). This includes the mathematical demands of the tasks involved in teaching, including knowing how to solve problems, responding to student questions, and checking answers. Teaching mathematics encompasses all that teachers do to support their students' learning (Ball et al., 2008). This can consist of components such as planning, evaluating, writing, grading, and explaining. Figures 1 and 2 below are questions from Content Knowledge for Teaching Mathematics instrument, which is used to assess a teacher's MKT (Ball et al., 2008). These questions represent scenarios similar to what a teacher would encounter in their elementary classroom. The teacher's selected responses to the questions are what help in assessing that teacher's MKT.

Figure 1 is used to assess a teacher's ability to understand students' ways of thinking and solving of a problem. Not only must a teacher be able to find the correct answer using the formal method for solving but must also be able to interpret unusual student answers or algorithms. Figure 2 is used to assess a teacher's understanding of the conceptual reasoning behind the rules of mathematics. The response to the question shows whether or not a teacher is able to explain to students why such mathematics rules were created and work.

Imagine that you are working with your class on multiplying large numbers. Among your students' papers, you notice that some have displayed their work in the following ways:

Student A	Student B	Student C
35	35	35
x 25	x 25	x 25
125	175	25
+75	+700	150
875	875	100
		+600
		875

Which of these students would you judge to be using a method that could be used to multiply any two whole numbers?

	Method would work for all whole numbers	Method would NOT work for all whole numbers	I'm not sure
a) Method A	1	2	3
b) Method B	1	2	3
c) Method C	1	2	3

Figure 1. **Content Knowledge for Teaching Mathematics Sample Question One**

Ms. Harris was working with her class on divisibility rules. She told her class that a number is divisible by 4 if and only if the last two digits of the number are divisible by 4. One of her students asked her why the rule for 4 worked. She asked the other students if they could come up with a reason, and several possible reasons were proposed. Which of the following statements comes closest to explaining the reason for the divisibility rule for 4? (Mark ONE answer.)

a) Four is an even number, and odd numbers are not divisible by even numbers.

b) The number 100 is divisible by 4 (and also 1000, 10,000, etc.).

c) Every other even number is divisible by 4, for example, 24 and 28 but not 26.

d) It only works when the sum of the last two digits is an even number.

Figure 2. Content Knowledge for Teaching Mathematics Sample Question Two

Mathematical knowledge for teaching can be divided into smaller domains that focus on more specific types of knowledge (Ball et al., 2008). The first domain is common content knowledge. This refers to the mathematical knowledge and skills that not only teachers but others outside of the school setting have (Ball et al., 2008). Common content knowledge is knowledge that can be applied to a wide variety of settings and situations. Those who are not teachers with a substantial background in mathematics have this type of mathematical content knowledge. The second domain is specialized content knowledge. This is the type of mathematical knowledge and skill that is unique to teaching (Ball et al., 2008). Specialized content knowledge includes the unique understanding and reasoning that is required of teachers so that they are able to unpack the concepts and make them more accessible to their students. The third domain is knowledge of content and students, which refers to the ability to anticipate what students are going to think and students' common conceptions and misconceptions (Ball et al., 2008). The final domain is knowledge of content and teaching, which pertains to the mathematical content being taught and the instructional options and purposes available to use (Ball et al., 2008). Knowledge of content and teaching requires using a mixture of content knowledge and pedagogical knowledge.

All elementary education teachers have mathematical knowledge for teaching to some degree. As stated earlier, with the new CCSS for mathematics being implemented on a national level, the effectiveness of these standards will strongly be influenced by teacher's instruction, knowledge, and understanding of the new, rigorous standards (Ball et al., 2005). The relationship between mathematical knowledge for teaching and instructional quality and effectiveness has been the central topic for many studies (Hill & Charalambous, 2012; Holzberger et al., 2013). In a cross-case analysis, Hill and Charalambous (2012) found teachers who had higher mathematical knowledge for teaching had higher quality instruction based on factors such as the use of mathematical language, clarity of mathematical explanations, connections made across multiple ideas and representations, the linking of lessons in order to help students gradually build their knowledge and skills, and using student work during instruction to capitalize on student ideas. Ball et al. (2005) also found that the quality of mathematics instruction was dependent on the teacher's knowledge of the content. This finding was based on a study conducted by Ball et al. (2005) where researchers examined the relationship between MKT and the size of student gains on a standardized mathematics test. Results showed that teachers' performance on the MKT test was a significant predictor of the magnitude of student gain scores on the standardized mathematics test (Ball et al., 2005). The need for teachers to have higher MKT also impacts student score gains because of its effect on a teacher ability to handle tasks such as error analysis, explaining procedures multiple ways, choosing examples to achieve a certain purpose, encountering unconventional solutions, and assessing the content in a textbook (Ball et al., 2008; Hill & Ball, 2009).

Summary

After surveying the literature, three themes were found across studies in the various topics. These themes relate back to the overarching question, “How is elementary teachers’ mathematical knowledge for teaching related to their self-efficacy in teaching the mathematical content to students?”

- The pedagogical content knowledge needed by elementary teachers in regards to mathematics goes beyond the simple facts and procedures. Teachers need to have a deep conceptual understanding of the informal ideas students bring when students are introduced to a mathematical idea for the first time. Teachers must be able to unpack concepts to make them more accessible to students through bridging the gap between students’ informal thinking and the formal ideas that go along with the concepts.
- Mathematical knowledge for teaching is related to multiple factors that work together to increase the quality of instruction.
- Teaching efficacy can affect teacher performance and quality of instruction in the classroom. It has also been found to have an effect on student achievement outcomes.

CHAPTER THREE: METHODOLOGY

This study examines how elementary teachers' mathematical knowledge for teaching related to their self-efficacy in teaching the mathematical content to students. It specifically looks at their self-efficacy for mathematics pedagogy and their self-efficacy for teaching mathematics. The three research questions that guided the study are as follows: What is the relationship between mathematical knowledge for teaching and self-efficacy for mathematics pedagogy? What is the relationship between mathematical knowledge for teaching and self-efficacy for teaching mathematics content? What factors contribute to successfully implementing the Common Core State Standards for Mathematics, as well as the factors that hinder the implementation of those same standards?

Participants

The participants in this study are educators in grades K-5. These educators are involved in the Improving Teachers' Monitoring of Learning Grant (ITML). The ITML grand is a 3-year grant award from the Institute for Education Sciences to study the influence of formative assessment and mathematics professional development on teachers and their students. Teachers involved with this grant were placed in one of four treatment groups. The particular group of educators involved in this study received professional development in both formative assessments and mathematics.

Demographics

The only demographic information collected during this research was the first name and last initial on the survey. This was necessary to match participant scores for both of the data collection instruments. After the data were matched, all names were erased so that participants could not be directly identified with the SETMI and CKT-M scores. That was the sole demographic information collected to maintain participant privacy.

Instrumentation

Mathematical Knowledge for Teaching

To determine the participants' MKT, the Content Knowledge for Teaching Mathematics (CKT-M) inventory was used (Hill et al., 2004). The CKT-M sub-construct that was used was *Elementary School Number Concepts and Operations*. The CKT-M multiple choice questions measure teachers' MKT, in other words, it identifies and measure the unique skills and capabilities teachers might need to draw upon while teaching (Hill et al., 2005).

Self-Efficacy for Teaching Mathematics Instrument

To assess participants' perceptions of their self-efficacy in regards to the content and teaching of mathematics, the Self-Efficacy for Teaching Mathematics Instrument (SETMI) was administered. Participants were asked to complete this survey using a web-based survey system. This instrument includes 22 questions that assess teachers' self-efficacy for pedagogy in mathematics (items 1-7), and self-efficacy for teaching mathematics content (items 8-22). The questions use a five point Likert scale assessing how well the participant, from a teacher's perspective, can complete the task in the questions from “A Great Deal” to “None at All”. (See Appendix B for the complete list of questions.) Six of the questions regarding teaching mathematics content were either altered or replaced to align better with the CCSS-M.

Two short-response items were added to the end of the SETMI. These two questions focused on the Common Core State Standards:

- What factors contribute to your success with the implementation of the Common Core State Standards for Mathematics?
- What factors inhibit your ability to implement the Common Core State Standards for Mathematics?

This qualitative data was collected to see if the themes of confidence or mathematical knowledge would appear as either positive or negative factors in the teachers’ implementation of the CCSS-M. Collecting qualitative data in addition to the SETMI and CKT-M scores was also important if results showed no relationship between either of the SETMI constructs and the CKT-M scores.

Data Collection and Timeline

Participants had previously completed a MKT assessment at the beginning of the grant, three months before the start of this study, as part of their participation. These scores were used during data analysis. This survey data was used to compare teachers’ MKT and self-efficacy in regards to mathematics.

Participants received emails with the web site link that directed them to the online survey site to complete the SETMI. The email included background information to the study, the purpose of the study, as well as the link to participate in the study. They were asked to complete the SETMI within two weeks of receiving the first email. Participants received three emails requesting their participation. The first email was sent out December 31, 2014. The second and third emails were sent out January 5, 2015 and January 11, 2015. The data for the survey was collected strictly online. The results from the CKT-M were collected from a subset of teachers in the ITML grant. This convenience sample selected was the subset of teachers from the grant that were receiving both the mathematics and formative assessment professional development. After the scores for both instruments were matched, all names were removed. Only nineteen of the thirty-five participants that were contacted submitted their complete survey during the allotted time frame. This is a response rate of 54%. Participant's first name and last initial were initially on the SETMI survey to help match these scores with the MKT scores. After the data had been matched, all names were erased so participants could no longer be identified.

Data Analysis

The reliability of the SETMI was analyzed using Cronbach Alpha. The self-efficacy for mathematics pedagogy subscale consisted of 7 items with a Cronbach alpha of .87. The self-efficacy for teaching mathematics content consisted of 15 items and had a Cronbach alpha of .91. The means and standard deviations for the responses for each participant were calculated. This analysis allowed each participant to have an average score for each of the two constructs of the SETMI.

Participants completed the CKT-M test before the start of this research. The specific CKT-M given was the sub construct called *Elementary School Number Concepts and Operations*. The scores were collected in the online administration system, TKAS. The scores were then reported in standardized z-scores, representing how many standard deviations away from the mean each participant's score was. The mean is zero. A negative z-score would signify that a participant's score was below the mean and a positive z-score would indicate that the participant's score was above the mean. Pearson Product Moment Correlation was used to test whether there was a relationship between participants' scores on the CKT-M and their scores on the SETMI. If a relationship were to be found it would not signify a causal relationship. A relationship does not mean causation, one variable did not cause a change in the other variable.

The final portion of the analysis involved the qualitative data from the two short response questions. The analysis technique used for qualitative data was the general inductive approach from Thomas (2006). This approach requires the condensing of raw textual data through summarization, then establishing links between the summaries and the objectives of the research, and finally discovering the underlying themes within the response summaries. Due to the low number of responses, only an initial level of coding could be done.

CHAPTER FOUR: RESULTS

The two quantitative research questions were "What is the relationship between mathematical knowledge for teaching and self-efficacy for mathematics pedagogy?" and "What is the relationship between mathematical knowledge for teaching and self-efficacy for teaching mathematics content?" A third qualitative research question was added in to assess the factors that participants believed either positively or negatively contributed to their implementation of the Common Core State Standards in Mathematics: "What factors contribute to successfully implementing the Common Core State Standards for Mathematics, as well as the factors that hinder the implementation of those same standards?"

Cronbach Alpha

A Cronbach Alpha test was run to check the reliability of the data from the SETMI. The self-efficacy for mathematics pedagogy subscale consisted of 7 items with a Cronbach alpha of .87. The self-efficacy for teaching mathematics content consisted of 15 items and had a Cronbach alpha of .91, indicating a high reliability.

Descriptive Statistics

Overall the average score for the first construct of the SETMI, self-efficacy for mathematics pedagogy, showed that teachers felt they could perform that task "quite a bit" with an average of 3.95 and a standard deviation of .49. The second construct of the SETMI, self-efficacy for teaching mathematics content, was slightly lower, with an average score of 3.60 and a standard deviation of .50. After analyzing the average scales for each participant in the two constructs of the SETMI, the decision was made to further look at the range in scores for each construct.

Further reflection on the scores for each of the SETMI constructs lead to the conclusion that there was a lack of variation among the scale scores. Participants could have scored on a scale of one to five, however the scores fell within a range of only 1.42 for self-efficacy for mathematics pedagogy and 1.60 for self-efficacy for teaching mathematics content. This small range in scores shows a lack of differentiation between teachers in regards to their self-efficacy. Figure 3 and Figure 4 show histograms of participants' averages for each of the constructs. These histograms reinforce that lack of differentiation between the teachers. An average score for this instrument would be a three, meaning that the participants felt they could perform the task asked to a strong degree. No participants' average score fell below a three for self-efficacy for mathematics pedagogy, and only two participants fell below a three for self-efficacy for teaching mathematics content.

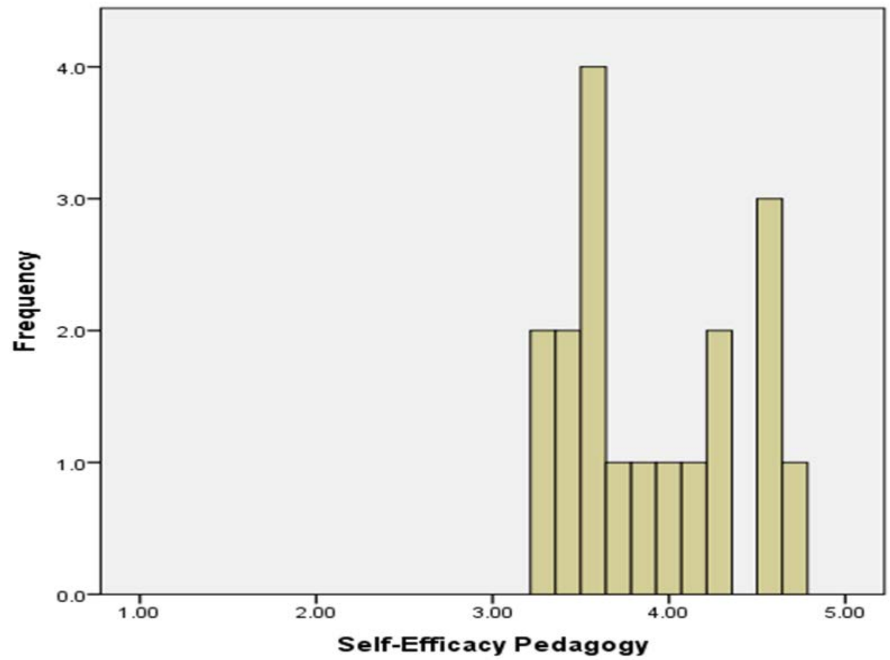

Figure 3. Histogram of Average Scores for Self-Efficacy for Mathematics Pedagogy

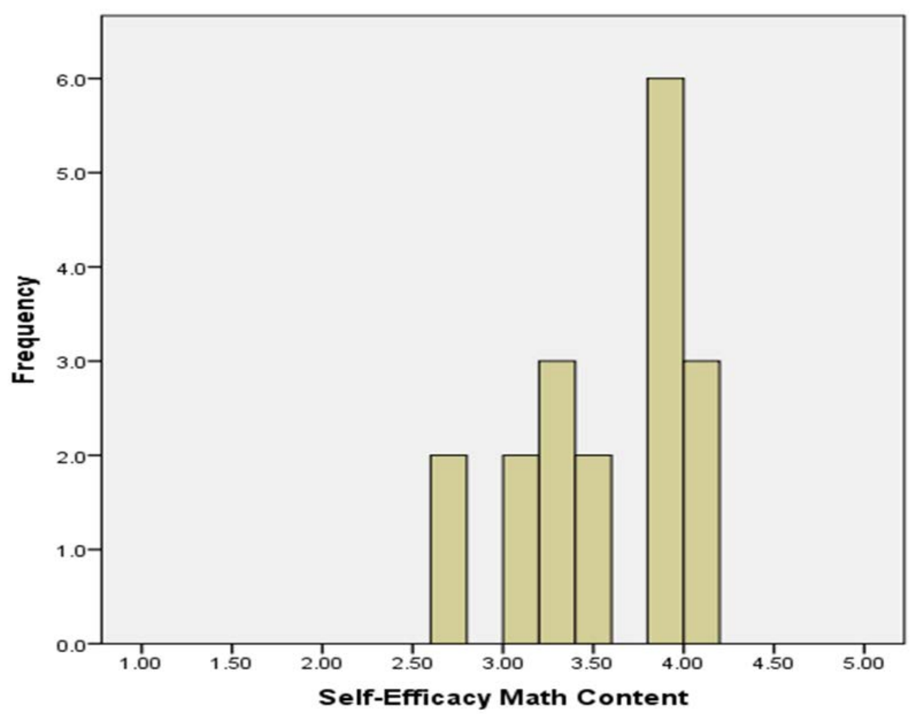

Figure 4. Histogram of Average Scores for Self-Efficacy for Teaching Mathematics Content

Figures 3 and 4 show the distribution of scores for self-efficacy for mathematics pedagogy and self-efficacy for teaching mathematics content. The range in scores shows how dispersed the scores were across the overall scale. The smaller the range, the more centralized and grouped together the scores for the sample were. The small standard deviations, .49 for self-efficacy for mathematics pedagogy and .50 for self-efficacy for teaching mathematics content, also show that there was not significant variation in the scores between participants in regards to both of the SETMI constructs.

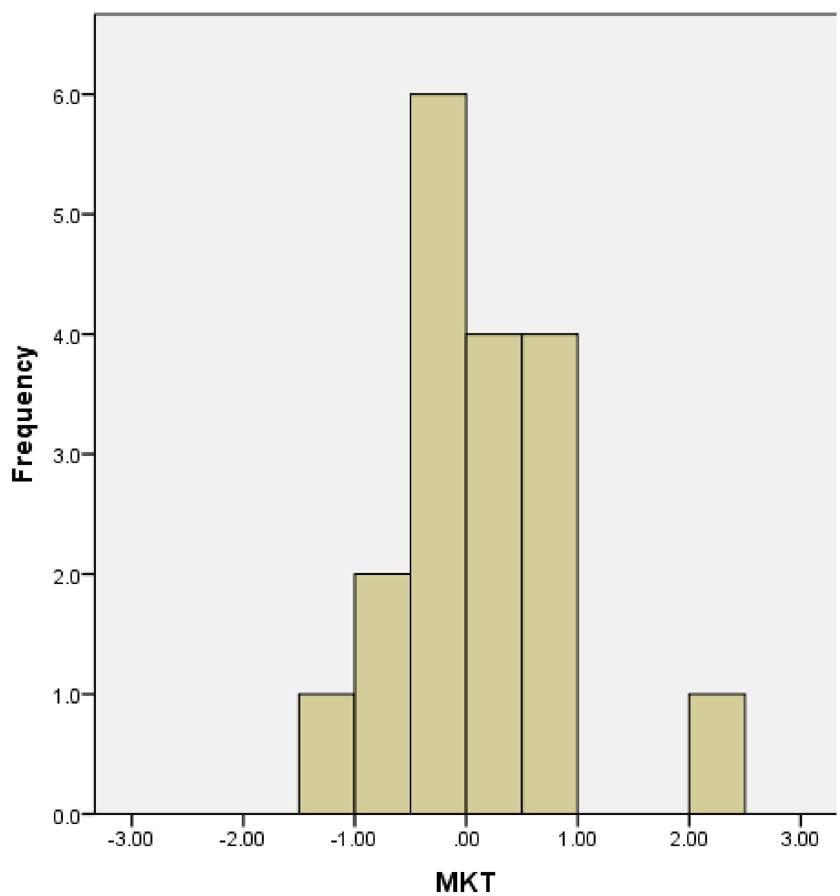

Figure 5. Histogram of Mathematical Knowledge for Teaching Scores

Figure 5 shows the distribution of scores from the CKT-M inventory. In regards to the collected scores, participants' mathematical knowledge for teaching scores, participants scored an average of .06 with a standard deviation of .72. The range in scores for the CKT-M was 3.16. There was one participant who did not have a CKT-M, so out of the eighteen scores collected of this sample, nine of the scores fell below the mean of zero. Falling below the standard deviation mean of zero means that the participant's score was below average for where it should be in regards to their content knowledge for teaching mathematics. There were also nine scores that fell above the population mean, showing that those participants had strong content knowledge for teaching mathematics.

Correlational Analysis

To address the first two research questions that looked at the relationship between the CKT-M scores that represent participants' MKT and the average for the SETMI constructs, a Pearson correlational analysis between the three variables (self-efficacy for mathematics pedagogy, self-efficacy for teaching mathematics content, and MKT). A Pearson product-moment correlation coefficient was computed to assess the relationship between participants' self-efficacy for mathematics pedagogy and their MKT. There was a non-significant, negative correlation between the two variables, $r = -.226$, $n = 18$, $p = .367$. A second Pearson product-moment correlation coefficient was computed to assess the relationship between participants' self-efficacy for teaching mathematics content and their MKT. There was a non-significant, negative correlation between the two variables, $r = -.051$, $n = 18$, $p = .842$. Figures 6 and 7 below summarize the results.

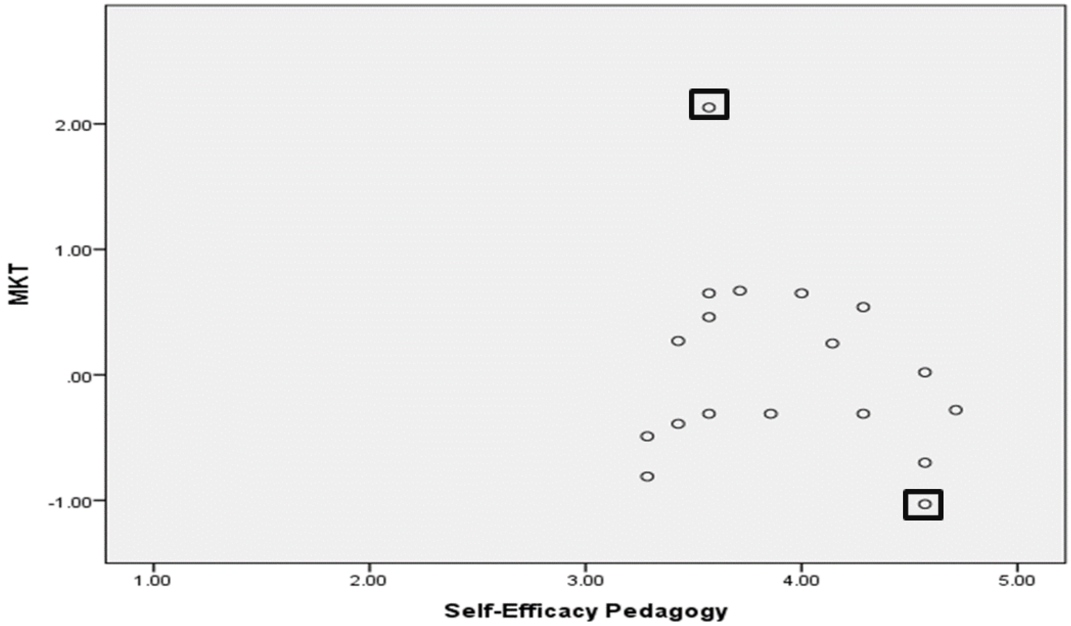

Figure 6. Scatterplot of Relationship Between Self-Efficacy for Mathematics Pedagogy and MKT Scores

Figure 6 shows the relationship between the scores for self-efficacy for mathematics pedagogy and MKT scores. This scatterplot supports the correlational analysis finding of there being no statistically significant relationship.

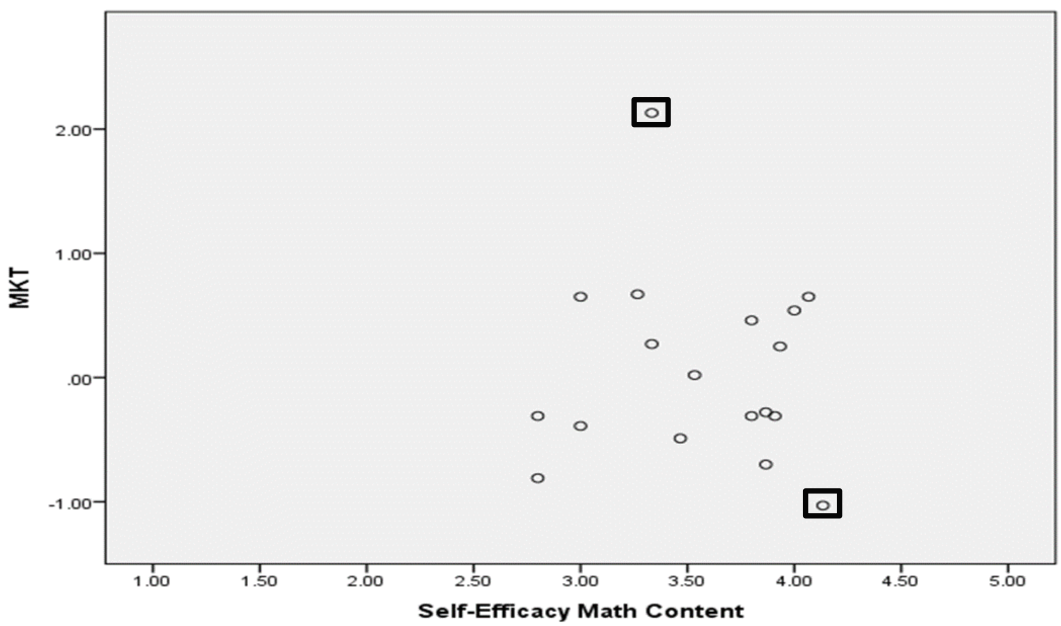

Figure 7. Scatterplot of Relationship between Self-Efficacy for Teaching Mathematic Content and MKT Scores

Figure 7 shows the relationship between the scores for self-efficacy for teaching mathematics content scores and MKT scores. This scatterplot supports the correlational analysis finding of there being no statistically significant relationship.

After analyzing both the scores for the two SETMI constructs as well as participant scores on the CKT-M, further inquiry went into looking at each individual participant's scores for the three different variables to see if there were any evident sets of scores that did not align. The boxed plotted points in Figures 6 and 7 above are instances where there appears to be a discrepancy in how participants rated their self-efficacy and their MKT scores. It would be expected that participants who tended to rate their self-efficacy lower would perform lower on the CKT-M test. What is intriguing about these data when presented this way is looking at the participants who rated their self-efficacy on the high end of the scale, with a maximum of five, yet performed below the mean in regards to their CKT-M results. This represents disconnects between where the participants believe they are with their confidence in their mathematical ability and where they more realistically are in regards to their mathematical knowledge for teaching. This raises the question of how aware are teachers of their true level of mathematical knowledge for teaching and do they know the depth of knowledge that they truly need?

Qualitative Data

Short response questions were used to address the third research question that concentrated on participants' views on factors that impacted their implementation of the new CCSS for mathematics in their classroom. Responses to the two questions varied in length from one to two words to full paragraphs. Due to only 19 surveys being returned with responses, Thomas's (2006) general inductive approach of qualitative research was used. This approach focuses on the bigger themes or categories that appear to be the most relevant to the research questions.

For the first question, "What factors contribute to your success with the implementation of the Common Core State Standards for Mathematics?", training and support were identified at the two major themes throughout the responses. Of the nineteen responses, 32% of the responses fell into the category of training and 26% of the responses included support. After further examination, it appeared that the two major themes seemed to have an overlap in the responses. Many responses included both training and support being factors that contributed to their success. An example of a response that included both of the major themes is "Additional training and support have been the number one factor. At our building we've been especially fortunate to have support from BSU through the ITML project and an awesome math coach…I really appreciate this level of support."

For the second short response question, "What factors inhibit your ability to implement the Common Core State Standards for Mathematics?", 26% of the responses included curriculum/resources as an inhibiting factor in the implementation. Two examples of participants' responses with the theme of curriculum/resources were "I feel like I am constantly hunting or cherry-picking for materials and innovative ways to do things with my students in math." and "A lack of easily available and accessible materials and lessons." The second identified theme was time, which was found in 47% of the responses. An example of a response that included the theme of time was "The time to look through a variety of resources to find the BEST lessons, materials, assessments. Time to create independent practice and assessments that are meaningful to students."

CHAPTER 5: DISCUSSION

The main purpose of this study was to examine if there was a relationship between elementary teachers' mathematical knowledge for teaching and their self-efficacy in teaching the mathematical content to students. In addition I examined teachers' perceptions of factors that both contributed, as well as inhibited, their implementation of the Common Core State Standards for Mathematics in their classroom.

Relationship between SETMI Constructs and CKT-M Scores

Results of the correlational analysis between the two SETMI constructs and the CKT-M scores found there to be no statistically significant relationships. The correlation between self-efficacy for mathematics pedagogy and the CKT-M scores was found to not be statistically significant, answering the first research question, "What is the relationship between mathematical knowledge for teaching and self-efficacy for mathematics pedagogy?" with there being no statistically significant relationship between these two variables. To answer the second research question, "What is the relationship between mathematical knowledge for teaching and self-efficacy for teaching mathematics content?" The correlational analysis also found there to be no statistically significant relationship between mathematical knowledge for teaching and self-efficacy for teaching the mathematics content. The lack of statistically significant relationships leads to the question of whether or not a larger sample size, or a random sample instead of a convenience sample, would lead to different results? A larger sample would provide more data points in the analysis to help decrease the effect of outliers. A random sample would help lessen the impact of extraneous factors, such as professional development received, on both the CKT-M and SETMI scores. I also believe that the lack of range in the scores for self-efficacy in this study highlights a possible issue with the validity of the self-efficacy survey instrument used. The lack of spread in the respondent scores could indicate a problem with the survey scale not providing enough differentiation among the teachers in terms of their feelings of self-efficacy. This may an issue with the scale, the survey items, or the sample population. This small range could also be due to the homogeneous nature of the sample selected. All of the teachers had been receiving additional mathematics professional development through the ITML grant. Participants had been receiving identical instruction during this professional development, which could have possibly molded their beliefs towards more similar views among one another, resulting in the scores being grouped together.

Results from the correlational analysis revealed some discrepancies between participants' SETMI scores and their actual MKT scores. These discrepancies were instances were the variables were inversely related. An example of this discrepancy was a participant with a MKT score of 2.13, one of the highest MKT scores of the sample, and their SETMI scores showing low self-efficacy with 3.57 for self-efficacy for mathematics pedagogy and 3.3 for self-efficacy for teaching mathematics content. Another example was a participant with a MKT score of -1.03, the lowest MKT score of the sample, and their SETMI scores showing high self-efficacy with 4.57 for self-efficacy for mathematics pedagogy and 4.13 for self-efficacy for teaching mathematics content. When relating these discrepancies to the overall high average for both SETMI constructs, 3.95

and 3.60 on a scale of 1-5, I revisited the research findings from Wheatley (2002) and assessed whether these high self-efficacy, or teaching efficacy, scores were a positive finding. These discrepancies between the two instrument scores and the overall high SETMI averages raised the question of whether or not these participants are good judges of their MKT or their need for professional development opportunities. According to Wheatley, it can be more beneficial for teachers' learning to have teaching efficacy doubts, in regards to being accepting of both educational reform and change or modification to their instruction. The discrepancies found between the two instruments' scores would indicate the participants are not accurate judges of their MKT. The high average SETMI scores would indicate that participants would be less likely to be open to change, self-reflection, motivation to learn, productive collaboration, or implementing new teaching techniques (Wheatley, 2002).

Qualitative Analysis

The qualitative data for this study were used to answer the third research question, "What factors contribute to successfully implementing the Common Core State Standards for Mathematics, as well as the factors that hinder the implementation of those same standards?" Participants responded to two short response questions pertaining to positive and negative factors in their implementation of the CCSS. The two themes regarding positive factors were training and support. Based on the responses, these two themes appeared to be connected. Participants appreciated the trainings they received through in-service days and participating in group training, such as the ITML grant trainings. These trainings also gave a sense of support to the participants and provided the additional skills and resources to help them make the implementation of the CCSS as successful as they could make it. Participants were provided with contact information for professionals they could contact to answer any additional questions, adding an additional level of support outside the immediate school.

The two factors that participants reported inhibiting their successful implementation of the CCSS were curriculum/resources and time. These too overlapped in responses. It appeared that many participants felt short of time to find appropriate curriculum and resources they needed to provide their students with the best instruction. Providing teachers with additional trainings that focus on how to find the best resources could prove to be beneficial in resolving the time demand problem that teachers expressed in their responses. This would help teachers maximize their time rather than searching blindly through curriculum resources during a time where they could be preparing student lessons.

Limitations

One limitation of this study is the small sample size. The sample size began at thirty-five participants. The response rate was 54%, with only nineteen participants completing the survey after receiving the emails. This small size is a limitation because it lacks a true representation of the population. Because of the lack of representation of the general population, it is hard to draw an overall conclusion for the population based on the data.

A second limitation is the homogeneity of the study sample. The sample was selected as a convenience sample with the participants being chosen due to their participation in the ITML grant. This method of selecting participants has the potential to cause the sample to once again not be representative of the larger teaching population.

These teachers were receiving additional training and support from the ITML grant, which could skew their confidence in their mathematics teaching ability as well as skew the results. The ITML grant included professional development explicitly relating to mathematics, more specifically looking at how to assess students' mathematics progress and multiple instructional models that could be used to enhance instruction. Participants also worked to build an understanding of how to address students' ideas, misconceptions, and challenging students conceptually through encouraging the use of multiple strategies and models. This training helps to increase the confidence that a teacher felt towards their mathematics teaching ability regardless of where their confidence was at before the training.

A third limitation is the timing of data collection. The data were collected throughout the month of winter break and then an additional week after that. Participants were contacted through their school email accounts with the thesis research information, which they may not have checked during the entirety of winter break. This may have contributed to the lower response rate.

Recommendations

Based on the findings from this study, there are three recommendations for further research: analyze the disconnect between teachers' perception of their MKT and their actual MKT, use larger random sample, and use an alternative self-efficacy for teaching mathematics instrument. The first recommendation for further research would be to look more deeply into the disconnect between teachers' perception of what they can do and their actual mathematical knowledge for teaching. A second recommendation would be to conduct this type of study using a large, simple random sample. A random sample would help in negating any large outside factors, such as the participation in the ITML grant, which could have had a large influence. Due to all of the participants being a part of a grant that provided mathematics instruction professional development, the sample was homogenous. A larger, random sample would also help in being able to better generalize the findings to the overall population and provide a more heterogeneous sample of participants. The third and final recommendation would be to look into a better self-efficacy survey instrument. A better self-efficacy survey instrument would show more differentiation between participants' self-efficacy for teaching mathematics. This recommendation relates to there being a lack of spread in participants' perceived self-efficacy scores for both constructs in this study.

Conclusions

The basis for this study came after discussions with pre-service teachers as well as current elementary teachers and their dislike towards mathematics. They expressed both a lack of confidence in the content and the pedagogical skills needed to teach it effectively. Confidence can also be referred to as self-efficacy, which once again according to Bandura (1993) is one's beliefs about his or her actions in order to perform a task successfully.

To assess on the mathematical knowledge for teaching that is required of elementary teachers, the CKT-M was used. Because the process for the selection of the sample, scores for the CKT-M were already collected. For a future study, I would look to collect this data again at the same time as the SETMI data, instead of using existing data. This would help in being able to better analyze the participants responses to the CKT-M questions in comparison to their perceived self-efficacy.

The overall results from this study showed that there was no statistically significant relationship between either of the two self-efficacy constructs and the CKT-M scores. These results prove my original hypothesis wrong. The self-efficacy as reported by elementary teachers does not have a relationship with their mathematical knowledge for teaching.

Due to the type of sample and the sample size, it would be recommended that this study be replicated with a larger random sample to gain more data on these possible relationships. The replication and larger number of participants would allow this study to be more generalized to the entire population of elementary teachers. As more research studies are conducted on this topic, specific attention should be paid towards extraneous factors, such as additional training participants are receiving, the timing of data collection, and possibly selecting a different instrument for assessing the self-efficacy for teaching mathematics that better differentiates between participants.

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APPENDIX

Self-Efficacy for Teaching Mathematics Instrument

Self-Efficacy for Teaching Mathematics Instrument (SETMI)

Elementary Teacher Version

Directions: Please circle the number that matches your response.

None at All	Very Little	Strong Degree	Quite a Bit	A Great Deal
1	2	3	4	5

1.	To what extent can you motivate students who show low interest in mathematics?	1	2	3	4	5
2.	To what extent can you help your students' value learning mathematics?	1	2	3	4	5
3.	To what extent can you craft relevant questions for your students related to mathematics?	1	2	3	4	5
4.	To what extent can you get your students to believe they can do well in mathematics?	1	2	3	4	5
5.	To what extent can you use a variety of assessment strategies in mathematics?	1	2	3	4	5
6.	To what extent can you provide an alternative explanation or example in mathematics when students are confused?	1	2	3	4	5
7.	How well can you implement alternative teaching strategies for mathematics in your classroom?	1	2	3	4	5

How well can you teach students to…

8.	Describe characteristics of Numbers (i.e. whole numbers, fractions, decimals)	1	2	3	4	5
9.	Perform strategies for composing and decomposing numbers by manipulating place value in addition and subtraction	1	2	3	4	5
10.	Perform strategies for composing and decomposing numbers by manipulating place value in multiplication and division	1	2	3	4	5
11.	Express their reasoning	1	2	3	4	5
12.	Compare equivalence of fractions and decimals	1	2	3	4	5
13.	Interpret inverse relationships between operations (i.e. +, - and *, ÷)	1	2	3	4	5
14.	Represent numbers on a number line	1	2	3	4	5
15.	Collect, plot and interpret data (on any type of graph)	1	2	3	4	5
16.	Measure area and perimeter	1	2	3	4	5

17.	Move between enactive (i.e. unifix cubes) and iconic (i.e. bar model) representations	1	2	3	4	5
18.	Identify a mistake in a completed solution	1	2	3	4	5
19.	Measure the length of objects	1	2	3	4	5
20.	Discover and create mathematical patterns	1	2	3	4	5
21.	Interpret variables in an algebraic equation	1	2	3	4	5
22.	Solve contextual word problems	1	2	3	4	5

What factors contribute to your success with the implementation of the Common Core State Standards for Mathematics?

What factors inhibit your ability to implement the Common Core State Standards for Mathematics?