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The Impact of Common Core Mathematics Professional Development on Elementary
Mathematics Teaching Self-Efficacy and the Resulting Effects on their Student Achievement

By
Alissa Smith Lee

A Dissertation Submitted to the
Gardner-Webb University School of Education
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Education

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2019

Approval Page

This dissertation was submitted by Alissa Smith Lee under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

David Shellman, Ed.D.
Committee Chair

Date

Stephen Laws, Ed.D.
Committee Member

Date

Cheryl Lutz, Ed.D.
Committee Member

Date

Prince Bull, Ph.D.
Dean of the School of Education

Date

Dedication

This dissertation is dedicated to my loving husband Deon Lee and to those who have helped me achieve this milestone. I would like to express my deep gratitude to each one of you. For your love and support, I am eternally grateful.

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“I can do all things through Christ which strengthened me.” *Philippians 4:13*

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Abstract

The Impact of Common Core Mathematics Professional Development on Elementary Mathematics Teaching Self-Efficacy and the Resulting Effects on their Student Achievement. Lee, Alissa Smith, 2019: Dissertation, Gardner-Webb University, Self-Efficacy/Common Core State Standards for Mathematics/Instructional Practices/Professional Development/Student Achievement

The purpose of this mixed-method study was to examine the impact of professional development on elementary mathematics teaching self-efficacy as well as the influence of teacher self-efficacy on student achievement. Statistical t tests were used to analyze the dispersion of the teachers' personal mathematics teaching efficacy beliefs (PMTE) and mathematics teaching outcome expectancy efficacy beliefs (MTOE). To develop a broader perspective, a qualitative analysis of interview data was implemented. Unlike the results from the quantitative data, the qualitative data in this study revealed that meaningful participation in professional development increased teacher performance as well as enhanced their mathematical teaching efficacy. This study offers findings to administrators and district offices about the importance of developing mathematics teaching self-efficacy and mathematics professional development opportunities.

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Chapter 1: Introduction

Introduction of the Study

“Our students will only do better than we did if we educate them better than we were educated. So we have to make sure our kids graduate from school fully prepared for college and a career” (President Obama, 2009). Over the years, millions of dollars have been spent on education reform. Although education reform is not solely to blame for the poor performance of students on standardized achievement tests, it remains true that student achievement has slightly improved under past reformations (Konstantopoulos, 2006; Smith, 2004). According to Canada (2013), schools in the United States are failing.

Those of us in education have held onto a business plan, that we don't care how many millions of young people fail. We are going to continue to do the same thing that did not work and nobody is getting crazy about it ... Enough is Enough. (Canada, 2013, 1:18)

Teaching is one of the most difficult professions in the world (Dorward & Hadley, 2011; Odden, 2013). Teachers have to identify differences in student learning styles to effectively differentiate instruction that meets the needs of all students (Felder & Brent, 2005). In today's society, a teacher's success does not depend solely on their performance but is defined primarily by their student's standardized test scores (Johnson, 2017; Konstantopoulos, 2006).

Statement of Problem

According to 46 country reports, students in the United States are falling behind students in other countries (Barshay, 2015; Brown, 2015; Fensterwald, 2013; Heim,

2016; Whitehurst, 2015). The Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) conducted international studies on student performance in reading literacy, mathematics literacy, and science literacy (Loveless, 2017). The PISA assessment was developed by the Paris-based Organisation for Economic Cooperation and Development (OECD) to assess how 15-year-old students reproduced and applied knowledge and skills every 3 years (OECD, 2016). According to OECD (2002), “PISA organizes mathematical competency into three classes: reproduction, definitions, and computations; connections and integration for problem-solving; mathematization and mathematical thinking, generalization, and insight” (p. 5). More than 500,000 students took the 2015 assessment across 72 countries and educational systems (Heim, 2016; Kerr, 2016). Thirty-six of 65 countries outperformed the United States in 2012, and 35 of 72 countries outperformed the United States in 2015 (Loveless, 2017; OECD, 2016). PISA 2015 findings revealed that the United States rankings fell from 28 to 35 in comparison to other countries (OECD, 2016). The drop in 2015 constituted an 11-point decline in average scores for math students and a drop of 20 points below the international average (Heim, 2016, OECD, 2016).

Schleicher and Gilbert (2015) stated that mathematics has always been the most difficult subject for American students. “Students are often good at answering the first layer of a problem in the United States. But as soon as students have to go deeper and answer the more complex part of a problem, they have difficulties” (Schleicher & Gilbert, 2015, 46:06). Finland, one of the top ranking countries, has used PISA results to justify educational reforms that include less nationally high-stakes testing (Kupiainen, Hautamaki, & Karjalainen, 2009). The United States, in contrast, has responded to low

international rankings in mathematics assessments by requiring more high-stakes testing. Hendrickson (2012) discovered that unlike the United States, 96% of Finland students attend preprimary school at age six with class sizes being limited to no more than 20 students. Finland students begin 9 years of mandatory basic education at age seven. Finland assessments are used to inform instruction and ensure that instruction is on the right track. There are no high-stakes assessments until students turn 18 years of age and take a national matriculation test that includes math, a foreign language, science, and humanities subjects (Hendrickson, 2012; Kupiainen et al., 2009).

TIMSS has conducted similar studies on students in Grades 4 and 8 since 1995 in math and science (Loveless, 2017). Every 4 years, TIMSS analyzes mathematics achievement on four international benchmarks: advanced, high, intermediate, and low (National Center for Education Statistics [NCES], 2015). At the fourth-grade level, 14% of U.S. students reached the advanced international benchmark in mathematics, 47% reached the high benchmark, 79% reached the intermediate benchmark, and 95% reached the low benchmark. For the first time, U.S. fourth graders scored an average of 539 of 1,000 possible points in math (Brown, 2015). This decline accounts for a 2-point decrease from the average 2011 TIMSS assessment. Since TIMSS was first administered in 1995, scores in the United States have shown a sluggish and unstable upward shift in overall school performance grades on the TIMSS assessment (Brown, 2015). The slight increase was among above-average students. Students in the bottom 25% always demonstrated trends of lower scores (NCES, 2015).

The National Assessment of Educational Progress (NAEP) study, also known as the Nation's Report Card, conducts testing nationally on various subjects every 2 years

(NCES, 2015). The NAEP study reports student achievement scores on three levels: basic, proficient, and advanced (NCES, 2015). Findings in 2015 revealed that fourth- and eighth-grade students across the United States scored lower than in 2013 (NCES, 2015). The percentage of fourth-grade students performing at or above proficiency on the 2015 NAEP assessment was 39%. Eighth-grade students performing at or above proficiency were 32% (NCES, 2015). Fourth-grade student test scores decreased by 1.3 percentage points and eighth-grade student test scores decreased by 2.4 percentage points from 2013 to the 2015 NAEP assessment (NCES, 2015). This was the first decline in scores since the federal government began administering the assessments in 1990 (Brown, 2015; NCES, 2015). In North Carolina, the 2015 scores showed that 44% of fourth graders and 33% of eighth graders were proficient in mathematics. Although North Carolina student percentages are higher than the nation, state scores have declined from the 2013 results (NCES, 2015).

Kane (2015) conducted a study “regressing the 2015 NAEP scores on the 2013 NAEP scores” (p. 1). Using average fourth- and eighth-grade scores on the Smarter Balance or The Partnership for Assessment of Readiness for College and Careers Ready assessments, Kane correlated student subgroup data to NAEP scores. Findings revealed that states that implemented the Smarter Balance or The Partnership for Assessment of Readiness for College and Careers Ready “underperformed states with similar 2013 NAEP scores by .8 scale score points (p-value=. 059)” (Kane, 2015, p. 1). A *p* value of .059 suggests that there is a 5.9% chance that states who implemented common core mathematics standards underperformed other states on the NAEP assessment by chance. “Hispanic students, students receiving Free/Reduced Lunch, and White students

underperformed by 1.917 (p-value=.006), 1.262 (p-value=.005), and 1.229 points (p-value=.010) points respectively” (Kane, 2015, p. 1). *P* values for the subgroups of students are very small. *P* values less than the alpha of .05 indicate that results did not occur by chance alone, and the results are statistically significant (Frost, 2015).

Therefore, it is very unlikely that the decline in scores for these subgroups was the result of random processes.

In order to improve mathematics achievement in the United States, Common Core State Standards (CCSS) were first implemented in 2010. CCSS have influenced instruction and assessments.

The current and anticipated influence of the CCSS on instruction, as well as the administration of CCSS-aligned assessments by many states, suggest the need to examine the alignment between the content covered by NAEP assessments and the content covered by the CCSS and its associated assessments. (NAEP Validity Studies Panel, 2015, p. ii)

Sarah Lubienski (2015), a professor of mathematics education at the University of Illinois at Urbana-Champaign and NAEP Validity Studies Panel (2015) analyzed NAEP mathematics scores based on subscales in five strands: number/operations, algebra, geometry, measurement, and data analysis. Their investigations suggest a moderate alignment for fourth-grade CCSS. At fourth grade, “alignment profile of NAEP to the Common Core State Standards across NAEP content areas” was as follows: “Algebra (62%), Data Analysis (47%), Geometry (68%), Measurement (96%), and Number Operations (90%)” (p. 8). The lowest strand, data analysis, is not studied in depth until sixth grade. Research also suggests a strong alignment for eighth-grade CCSS to NAEP

(NAEP Validity Studies Panel, 2015). At eighth grade, “alignment profile of NAEP to the CCSS across NAEP content areas” (p. 8) was as follows: Algebra (84%), Data Analysis (74%), Geometry (80%), Measurement (100%), and Number Operations (97%; NAEP Validity Studies Panel, 2015). Data analysis at Grades 4 and 8 and geometry at Grade 8 constitute an average drop in NAEP scores of 4.5 points from 2013 to 2015 (Lubienski, 2015). These findings of alignment between NAEP and the early implementation of CCSS may have contributed to the decline in NAEP test scores (Carr, 2018). The influence that CCSS and CCSS assessments have on instruction suggested the need for further research on the alignment between the content covered by NAEP assessments and the content covered by CCSS (Loveless, 2017).

The implementation of CCSS reflects the type of mathematics instruction that resembles that in high-performing countries. Standards prior to the implementation of CCSS resulted in weakness on higher cognitive demand task involving real-world situations and solving real-world problems because they tend to be “a mile wide and inch deep” (Achieve the Core, 2012, para 1). The more rigorous standards are far more demanding for teachers and students (Achieve the Core, 2012; Great Minds, 2016). Research by Bohrnstedt and Stancavage (2015) revealed that the decline in test scores may not be due to early implementation of CCSS. Evidence suggests that teachers need professional development on the understanding of the standards and how to adequately teach them to meet the needs of all students (National Council of Teachers of Mathematics [NCTM], 2014). Brown (2015) reported on a call that Arne Duncan, former Secretary of Education, had with Washington Post reporters. Duncan stated that

Massive changes in schools often lead to a temporary drop in test scores while

teachers and students adjust ... Big change never happens overnight. I'm confident that over the next decade if we stay committed to this change, we will see historic improvements. (p. 1)

Alignment studies between Common Core State Standards for Mathematics (CCSSM) and standardized test scores suggest that successful implementation of CCSS occurs when teachers have adequate professional development and hands-on experience with the curriculum (NCTM, 2014). As a result of successful implementation, international test scores rise and students develop mathematical literacy skills (Marzano & Toth, 2014).

Although test scores in the United States have declined, the dollar amount spent on education per pupil is steadily increasing. NCES (2015) reported that

Total expenditures for public elementary and secondary schools in the United States in 2013-14 amounted to \$634 billion, or \$12,509 per public school student enrolled in the fall (in constant 2015–16 dollars). Total expenditures included \$11,222 per student in current expenditures, which includes salaries, employee benefits, purchased services, and supplies Total expenditures, \$939 per student in capital outlay, and \$348 for interest on school debt. (p. 1)

Richmond (2016) suggested that “school funding, inadequate teacher training, and inequitable educational opportunities are frequent targets” (para. 4) for the decline in U.S. student test scores. Regardless of the reason for the decline, America’s edge as a global competitor in the most competitive career fields that relate to mathematics and science has steadily vanished (Anderson, 2010). According to Peggy Carr, acting commissioner of NCES (as cited in Kerr, 2016), “This pattern that we're seeing in mathematics seems to be consistent with what we've seen in previous assessments.... Everything is just going

down?” (p. 1).

Context

This study was conducted in a rural county located in the southeastern region of North Carolina. There are six townships and the ninth largest county in the state with 933 square miles. The school district is the largest employer in the county. With a population of over 56,000, the county is ranked one of the fastest growing counties in the state and 98th fastest growing in the nation. According to WECT TV-6 (2015), the county was the 10th highest county in North Carolina for growth but ranks 109 of 115 in North Carolina Local Education Agencies for the total per-pupil expenditure for 2014-2015 funding.

There are 16 schools with eight elementary schools. There are approximately 9,331 students with 4,249 elementary students and 250 elementary teachers. Teachers from all of the district’s eight elementary schools participated in this mixed-method study. Five of the eight elementary schools are currently receiving Title I Funding. Title I funding targets schools with at least 40% of children from low-income families. These funds are used to service students who are failing or at risk of not meeting proficiency on state standardized tests (U.S. Department of Education, 2013).

Purpose

Bandura (1986) defined self-efficacy as “people's judgments of their capabilities to organize and execute courses of action required to attain designated levels of performance” (p. 391). Tschannen-Moran and Woolfolk Hoy (2001) defined teacher 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). Studies revealed a strong relationship between teacher efficacy and student achievement (Alrefaei, 2015; Gallagher, 2002; Harris, 2010). These findings lead to further investigations, which help identify factors that influence the development of a sense of efficacy among teachers (Mohamadi & Asadzadeh, 2012). Research suggests that elementary teachers usually are not the mathematical content specialist; therefore, they must acquire the skills needed to provide effective instruction on the most current teaching methods and pedagogy (Dorward & Hadley, 2011; Novak & Tassell, 2017). Lack of content skills often results in anxiety for many elementary teachers (Dorward, & Hadley 2011; Reed, 2014).

Math anxiety. To address the decline in elementary student’s mathematics tests scores, part of the answer lies in addressing and reducing mathematics anxiety (Dorward & Hadley, 2011; McAnallen, 2010; Novak & Tassell, 2017; Reed, 2014). Over the years, mathematics has become a subject that causes anxiety and fear for many teachers, especially elementary teachers (Dorward & Hadley, 2011). Many of them had experienced difficulties in their own K-12 and college mathematics careers, which has led to difficulties in their mathematics instruction (NCTM, 2014). “It’s not surprising that many elementary teachers struggle with the Common Core State Standards for Mathematics. Many early childhood teachers are actually frightened of math” (Raschka & Hemphil, 2015, p. 2). Numerous elementary mathematics teachers doubt their own ability and have chosen a profession where they think it will not matter (McAnallen, 2010). Distinct from the basic step-by-step algorithm, teachers are tasked with providing instruction that “builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as

they solve contextual and mathematical problems” (NCTM, 2014, p. 42). McAnallen (2010) conducted a study of 691 elementary teachers among eight states to determine if teachers who have mathematics anxiety also have anxiety about teaching mathematics. The highest level of mathematics that participants had taken was Algebra I in high school or a remedial mathematics course in college. The McAnallen Anxiety in Mathematics Teaching Survey (MAMTS), a newly developed instrument, was administered to the participants. Findings revealed that 33% of the participants indicated that they have math anxiety, which has decreased their delectation in mathematics. Twelve percent stated that their math anxiety started in primary school and 26% started in elementary school. Other reasons for the anxiety were attributed to negative elementary or secondary interactions with teachers.

Although many studies have found a positive relationship between anxiety about mathematics and anxiety about teaching mathematics, there has been no direct correlation between the anxiety variables and student mathematics achievement (Dorward & Hadley, 2011; Hadley, 2005; McAnallen, 2010; Novak & Tassell, 2017; Raschka & Hemphil, 2015). According to Hadley (2005), “efforts to decrease teachers’ anxiety about mathematics or anxiety about teaching mathematics as a means of improving student achievement may be unproductive” (p. 77) if the focus is solely on student achievement. Dorward and Hadley (2011) suggested that efforts should be made to make teachers feel comfortable about implementation through professional development opportunities which focus on improving understanding of the curriculum. As the North Carolina Department of Public Instruction (NCDPI) continues to revise curriculum to meet new requirements of the Every Student Succeeds Act (ESSA), school districts have an opportunity to

support and venerate teacher anxiety and build self-efficacy through meaningful professional development opportunities (Tschannen-Moran & Woolfolk Hoy, 2001).

ESSA. In attempts to force school districts to enforce adopted standards and raise national achievement, ESSA was signed into law on December 10, 2015 (ESSA, 2017). This law became in full effect during the 2017-2018 school year replacing No Child Left Behind (NCLB). Under ESSA, Adequate Yearly Progress (AYP) and Annual Measurable Objectives no longer exist (ESSA, 2017). Similar to NCLB, ESSA continues to require states to conduct standardized testing, report results by subgroup, and implement school accountability measures and autonomy over curriculum choice and decision-making. According to the U.S. Department of Education (2017), North Carolina implemented ESSA guidelines for the 2017-2018 school year as mandated by the department. In order to ensure that teachers and administrators are prepared to meet the needs of all students and meet ESSA guidelines, North Carolina continued to implement CCSS and assessments (NCDPI, 2015). As a result, the continuation of CCSS provided administrators and teachers access to rich curriculum, better preparing them for challenges in the classroom (CCSS, 2010; NCDPI, 2015). According to National Governors Association Center, Council of Chief State School Officers, and Achieve Inc. (2008), CCSS are internationally benchmarked; therefore, “students are equipped with the necessary knowledge and skills to be globally competitive” (National Governors Association Center, Council of Chief State School Officers, and Achieve Inc., 2008, p. 6).

CCSS. According to the Council of Chief State School Officers, CCSSM are Research- and evidence-based understandable, and consistent, aligned with

college and career expectations, based on rigorous content and application of knowledge through higher-order thinking skills, built upon the strengths and lessons of current state standards, and informed by other top performing countries in order to prepare all students for success in our global economy and society. (CCSS, 2010, p. 2)

Forty-two states as of August 2015 have adopted CCSS in English language arts/literacy and mathematics (Common Core State Standards Initiative [CCSSI], 2017). CCSSM were constructed to ensure that students possessed mathematics content and knowledge that will graduate them career and college ready upon completion of high school (CCSS, 2010). Career and college ready for all students can only be accomplished if teachers change and improve their pedagogy (CCSS, 2010). When teachers are afforded the opportunity to engage in learning about CCSSM, they understand what curriculum should be taught and how to teach and assess the curriculum to achieve student achievement and success (Achieve the Core, 2012; Great Minds, 2016). The implementation of CCSS has been the blame for the recent decline of the U.S. students' national test scores.

According to Whitehurst (2015), declines in test scores are never attributed to one factor. Whitehurst conducted an empirical study of NAEP results where he examined the difference in states that had fully implemented CCSS and assessed students through Smarter Balance or The Partnership for Assessment of Readiness for College and Careers Ready.

Twenty-eight states participated in a full blown Common Core assessment whereas 22 did not. A simple statistical analysis of the relationship between

Common Core testing and changes in 4th and 8th grade NAEP math scores between 2013 and 2015 were analyzed. The differences in the median NAEP scale scores are statistically significant. The correlation between Common Core assessment participation and changes in NAEP is $-.35$. This analysis is not causal, and the modest correlation suggests that more is going on than disruptions in instruction associated with the rollout of a new assessment system. In line with this, note that the median change for the states that did not participate in a Common Core assessment is negative too. (p. 3)

Additional research is needed to validate correlations between the implementation of the Common Core Curriculum, Common Core Assessments, and NAEP because both groups resulted in a negative correlation.

Successful implementation of CCSSM requires three major shifts along with the implementation of the Eight CCSSM Mathematical Practices (Achieve the Core, 2012; CCSSI, 2010; Engage NY, 2014; Great Minds, 2016; Lyons, 2012). The first major shift is Focus: Greater focus on fewer topics. Greater focus on fewer topics allows instruction on fewer topics called major works of the grade (CCSSI, 2010). “Rather than racing to cover many topics in a mile-wide, inch-deep curriculum, the standards ask math teachers to significantly narrow and deepen the way time and energy are spent in the classroom” (CCSSI, 2017, p. 1). The concepts focused in each grade strengthen foundation skills and provide students the toolbox to apply these mathematical skills inside and outside the classroom (Achieve the Core, 2012). “The major works of the grade for Grades 3-5 are concepts, skills, and problem solving related to multiplication and division of whole numbers and fractions” (CCSSI, 2010, para. 3).

The second major shift is Coherence: Linking topics and thinking across grades. CCSS were designed so concepts are coherent across grade levels and content areas. Students are expected to build upon concepts learned in previous years and in other content areas (CCSSI, 2010). Standards learned should not be a brand new experience but a building block. The third shift is Rigor: Pursue conceptual understanding, procedural skills and fluency, and application with equal intensity (Achieve the Core, 2012; Engage NY, 2014). CCSSI (2010) referred to rigor as a “deep, authentic command of mathematical concepts” (para. 7). Rigor is not intended to make the mathematics more difficult or provide students access to concepts at an early grade (Engage NY, 2014). Successful implementation of CCSS requires an understanding of the three shifts along with the implementation of the Eight Mathematical Practices (CCSSI, 2010).

The Eight Mathematical Practices provide mathematics expertise that all teachers should develop in their students. These practices build on the NCTM process standards (communication, representation, reasoning and proof, connections, and problem-solving) and the National Research Council's five strands of mathematical proficiency (procedural fluency, conceptual understanding, strategic competence, adaptive reasoning, and productive disposition; CCSSI, 2010; NCTM, 2014). It is imperative that all teachers possess knowledge of the Mathematical Practices. Ultimately, they are essential components of CCSSM (Achieve the Core, 2012; CCSSI, 2010; Engage NY, 2014; NCTM, 2014). Although the practices were written as eight separate items, they are interconnected in theory and implementation (McCallum, 2011). Figure 1 depicts the higher-order structure among the practices.

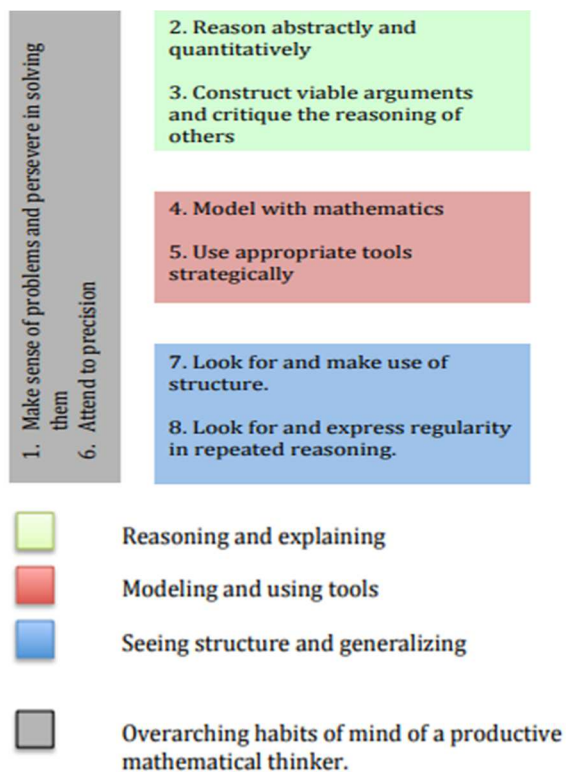


Figure 1. Structuring of the Standards of the Eight Mathematical Practices.

Practice 1: Make sense of problems and persevere in solving them and Practice 6: Attend to precision serve as overarches of the entire process in mathematical thinking problem-solving. Practice 2: Reason abstractly and quantitatively and Practice 3: Construct viable arguments and critique the reasoning of others focus on reasoning, explaining, and justifying. Practice 4: Model with mathematics and Practice 5: Use appropriate tools strategically are relevant for modeling and using appropriate tools. Practice 7: Look for and make use of structures and Practice 8: Look for and express regularity in repeated reasoning focus on recognizing structures and generalizing mathematical thinking (CCSSI, 2010; McCallum, 2011).

Reece (2014) conducted a qualitative study on elementary teacher perceptions of the implementation of CCSSM. The participants were asked how the implementation of

CCSS had changed their daily instruction. All participants stated that the standards have a positive effect on education and were more comfortable with implementation once they attended professional development sessions on CCSSM. Participants also stated that they felt pressured to assure that all standards were integrated throughout their curriculum. As a result, the participants felt that the depth of the standards provided their students content mathematical knowledge needed to make connections across grade levels and content areas and ultimately student achievement. “Standards don’t stay up late at night working on lesson plans or stay after school making sure every student teaches—its teachers who do that. And standards don’t implement themselves” (Coleman, Pimentel, & Zimaba, 2012, p. 1).

Significance

Teacher self-efficacy is the most influential factor on teacher beliefs, student motivation, and achievement (Tschannen-Moran & Woolfolk Hoy, 2001). Evidence suggests that the implementation of CCSSM has diminished teacher efficacy in mathematics instruction (Harris, 2010). The impact of CCSSM professional development on elementary mathematics teachers’ self-efficacy will inform development and training programs and subsequently lead to successful implementation of CCSSM. Upon completion of this study, school districts have data to improve administrator leadership, teacher instruction, and ultimately student achievement. Additionally, this study provided school and district leaders information on developing meaningful professional development based on teacher perception. Professional development based on teacher perception empowers teachers, builds self-efficacy, and supports the district’s learning and teaching agenda (Tschannen-Moran & Woolfolk Hoy, 2001). The effectiveness of

teachers is the ultimate component of student achievement. Teachers who are familiar with the curriculum possess less anxiety and are more apt to effectively implement the standards into their daily instruction (Reece, 2014).

Research Questions

The purpose of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured North Carolina end-of-grade (EOG) assessments was investigated. This research was designed to address the following questions:

1. What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers' mathematics teaching efficacy?
2. What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment?

Definition of Terms

AYP. A diagnostic instrument that determines the amount of annual growth a student achieves (NCLB, 2001).

CCSS. Standards created with the collaboration of many organizations, including teachers, parents, and content experts to provide rigorous mathematics and English language arts standards, adopted by many states, with a goal to ensure students in the U.S. are college and career ready upon graduation from high school (CCSSI, 2010).

CCSSM. Mathematics standards that were created to prepare graduates career and college ready for entry-level mathematics courses and career prep programs. The standards were designed based on information from state, national, and international standards (CCSSI, 2010).

ESSA. A law to improve educational equity for all students regardless of their socioeconomic status, family background, or ethnicity. This act ensures that all be afforded a quality education with the support they need to succeed (U.S. Department of Education, 2013).

NAEP. NAEP study, also known as the Nation's Report Card, conducts testing nationally on various subjects on what students know and can do every 2 years. NAEP reports student achievement scores on three levels: basic, proficient, and advanced in mathematics, reading, science, writing, U.S. history, geography, civics, the arts, and other subjects (NCES, 2015).

National Council of Chief State School Officers. Nonpartisan educational organization that provides advocacy on major educational concerns and leadership. The organization manages the Department of Education as well as the Department of Defense (CCSSI, 2017).

NCLB. A law that affected every public school. The goal was to provide equality to students who are disadvantaged, including students in poverty, minorities, students receiving special education services, and students with limited speaking and understanding of the English language (NCLB, 2001).

Professional development. The National Staff Development Council (NSDC, 2009) defined professional development as “a comprehensive, sustained and intensive

approach to improving teachers' and principals' effectiveness in raising student achievement” (p. 1).

Self-efficacy. Bandura (1986) defined self-efficacy as “people's judgments of their capabilities to organize and execute courses of action required to attain designated levels of performance” (p. 391).

Standards for Mathematical Practice. Standards that develop students as “practitioners of the discipline of mathematics increasingly ought to engage with the subject matter as they grow in mathematical maturity” (CCSSI, 2010, p. 8). The Eight Standards for Mathematical Practice are make sense of problems and persevere in solving them; reason abstractly and quantitatively; construct viable arguments and critique the reasoning of others; model with mathematics; use appropriate tools strategically; attend to precision; look for and make use of structure; and look for and express regularity in repeated reasoning (CCSSI, 2017, p. 8).

TIMSS. Provides data on the mathematics and science achievement of U.S. students compared to Grades 4 and 8 students in other countries every 4 years (TIMSS, 2015).

Theoretical Framework

This study builds on existing research of the relationships between mathematics teaching self-efficacy, professional development, and student achievement. Bandura’s (1977) theory provided the theoretical framework for this study. Bandura (1986) defined self-efficacy as “people's judgments of their capabilities to organize and execute courses of action required to attain designated levels of performance” (p. 391). Based on Bandura’s (1977) theory, the problem addressed in this study was whether participation

in a mathematics cohort enhances participant's mathematics teaching self-efficacy and mathematics achievement for their students.

Summary and Organization of Chapters

This study was designed to determine the level of elementary teachers mathematics teaching efficacy after participating in professional development that focuses on the main components of CCSSM: Focus: Greater focus on fewer topics; Coherence: Linking topics and thinking across grades; Rigor: Pursue conceptual understanding, procedural skills, and fluency; and the Eight Mathematical Practices.

This dissertation is organized into five chapters. Chapter 1 was the introduction that provides an overview of the study. The overview contains the statement of problem, purpose, research questions, the definition of key terms, and significance of the study. Chapter 2 contains a literature review providing a theoretical framework for this study. Best practices for teaching CCSSM are identified and described in this chapter. Mathematics teacher self-efficacy, measures of self-efficacy, and studies concerning mathematics teacher's self-efficacy are also investigated. Chapter 3 explains the methodology that was used in this study. It includes the participants and how data were collected, analyzed, and interpreted. Chapter 4 provides data from the study. The final chapter, Chapter 5, discusses the findings of the study and conclusions and provides suggestions for further research. The instrument used in this study, the Mathematics Teaching Efficacy Beliefs Instrument, can be found in Appendix A.

Chapter 2: Literature Review

Introduction

Chapter 2 is a review of literature that supports the study of the impact of CCSSM professional development on elementary teacher mathematics teaching efficacy.

Focusing on building teacher self-efficacy can boost teacher confidence and ultimately increase student achievement (Smith, 2010). Teachers are able to prepare students to be career and college ready only when they possess the confidence to execute their roles and responsibilities effectively (Marzano & Toth, 2014). The literature research in this chapter is organized in the following categories: CCSSM, teacher self-efficacy, mathematics teaching efficacy, measures of teacher self-efficacy, and effective mathematics professional development.

The purpose of selecting these topics is to provide a framework within their contexts and present an overview of past and current research. Each school district has an obligation to equip teachers with the toolbox needed to effectively implement CCSSM standards and ultimately prepare students for career and college readiness (CCSSI, 2010). “District offices can control one important pathway for influencing teaching: professional development” (Firestone, Mangin, Martinez, & Polovsky, 2005, p. 32). When teachers believe in their ability to do something well and persevere through the steps to get there, every child will attain success (Achieve the Core, 2012; Marzano & Toth, 2014; NCTM, 2014).

CCSSM

The adoption of CCSSM was an attempt by states to change mathematics teacher pedagogy, build conceptual understanding, and ultimately increase student achievement

scores (Achieve the Core, 2012; CCSSI, 2010). The standards were a response to the urgent need to prepare students for life, college, and career. “The Common Core State Standards offer a foundation for the development of more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning as well as skill fluency” (NCTM, 2013, p. 1). Successful implementation of CCSSM requires the transformation of teacher thinking and classroom instructional practices (Cobb & Jackson, 2011).

Kane, Owens, Marinell, Thal, and Staiger (2016) conducted research at the Center for Education Policy at Harvard University. The main objective of their study was to analyze the effects the implementation of common core has on student learning. One thousand five hundred fourth- through eighth-grade teachers as well as 142 principals from Delaware, Maryland, Massachusetts, New Mexico, and Nevada were randomly selected to participate in the study (Sparks, 2016). Respondents were asked about professional development they have received, resources used, observation on their instruction, and many other features of their Common Core implementation. In order to determine the success of Common Core implementation, their responses were compared to student achievement on Common Core-aligned assessments. Eighty-two percent of the respondents “reported that they have changed more than half of their instructional materials in response to the Common Core” (Sparks, 2016, p. 4). Math teachers indicated that emphasis on conceptual understanding, application of skills and knowledge, and procedural skills increased by 81%, 78%, and 39% respectively since the implementation of CCSS. The decrease in emphasis on procedural skills reflects a balance in the three major shifts, which requires more attention to building conceptual understanding (Sparks,

2016).

The Toolkit for Evaluating the Alignment of Instructional and Assessment Materials to the Common Core State Standards (National Governors Association, Council of Chief State School Officers, & Achieve Inc., 2013), was developed to align assessment and instructional material to the core features of CCSSM: focus, coherence, and rigor. The evaluation tool consists of four nonnegotiables.

The first non-negotiable criterion is the material should devote at least 65% and up to approximately 85% of class time to the major work of each grade with Grades K-2 nearer the upper end of the range. Next, materials should not assess probability; statistical distributions; symmetry; and similarity, congruency, or geometric transformations before they are introduced in the CCSSM. Third, the instructional materials reflect the balances in the Standards and help students meet the rigorous expectations, by helping students develop conceptual understanding, procedural skill and fluency, and application. The last non-negotiable criterion states materials must connect the practice standards and content standards and for each grade.

Focus. The first significant shift in achieving the core is focus. CCSSM are internally benchmarked; fewer and more rigorous; and aligned with life, college, and career readiness (Achieve the Core, 2012). CCSSI intended for the mathematics standards to be more focused. “To deliver on the promise of common standards, the standards must address the problem of a curriculum that is a mile wide and an inch deep” (CCSSI, 2010, p. 3). Cobb and Jackson (2011) stated that CCSS were focused “on a small number of core mathematical ideas at each grade” (p. 184). In the Hunt Institute (2011) video, Jason Zimba stated that

Focus means spending more time on fewer things at any given grade, principally

on number and operations in early grades. This is to give teachers more time to teach those things to mastery and give students a firm foundation on which to build. And the point is that math is not like a homogeneous fluid that can be ladled into bowls and served to students. It has a logical structure with lots of connections, some of them intricately. (3:55)

Schmidt, Houang, and Cogan (2002) reiterated the need for focus:

The curriculum that is enacted in the U.S. (compared to the rest of the world) is highly repetitive, unfocused, unchallenging, and incoherent.... Our teachers work in a context that demands that they teach a lot of things, but nothing in-depth. We truly have standards, and thus enacted curricula, that is a “mile wide and an inch deep.” (p. 1)

Outlined in Figure 2, the United States mathematics curriculum covers more topics per grade than A+ countries (Schmidt et al., 2002). Valverde and Schmidt (2000) devised the term A+ countries for top-achieving countries demonstrating the highest mean student achievement on the TIMSS assessment.

	A+ Composite: Mathematics topics intended at each grade by at least two-thirds of A+ countries.								State Composite: Mathematics topics intended at each grade by at least two-thirds of 21 U.S. states.							
TOPIC	GRADE: 1	2	3	4	5	6	7	8	GRADE: 1	2	3	4	5	6	7	8
Whole Number Meaning	■	■	■	■	■				■	■	■	■	■	■	■	■
Whole Number Operations	■	■	■	■	■				■	■	■	■	■	■	■	■
Measurement Units	□	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Common Fractions			□	■	■	■	■	■	■	■	■	■	■	■	■	■
Equations & Formulas			□	■	■	■	■	■	■	■	■	■	■	■	■	■
Data Representation & Analysis			□	□	■	■	■	■	■	■	■	■	■	■	■	■
2-D Geometry: Basics			□	■	■	■	■	■	■	■	■	■	■	■	■	■
Polygons & Circles				■	■	■	■	■	■	■	■	■	■	■	■	■
Perimeter, Area & Volume				■	■	■	■	■	■	■	■	■	■	■	■	■
Rounding & Significant Figures				■	■	■	■	■	■	■	■	■	■	■	■	■
Estimating Computations				■	■	■	■	■	■	■	■	■	■	■	■	■
Properties of Whole Number Operations				□	■	■	■	■	■	■	■	■	■	■	■	■
Estimating Quantity & Size				□	□	■	■	■	■	■	■	■	■	■	■	■
Decimal Fractions				■	■	■	■	■	■	■	■	■	■	■	■	■
Relationship of Common & Decimal Fractions				■	■	■	■	■	■	■	■	■	■	■	■	■
Percentages					■	■	■	■	■	■	■	■	■	■	■	■
Proportionality Concepts					■	■	■	■	■	■	■	■	■	■	■	■
Proportionality Problems					■	■	■	■	■	■	■	■	■	■	■	■
2-D Coordinate Geometry				□	■	■	■	■	■	■	■	■	■	■	■	■
Geometry: Transformations						■	■	■	■	■	■	■	■	■	■	■
Negative Numbers, Integers & Their Properties						■	■	■	■	■	■	■	■	■	■	■
Number Theory							■	■	■	■	■	■	■	■	■	■
Exponents, Roots & Radicals							■	■	■	■	■	■	■	■	■	■
Exponents & Orders of Magnitude							■	■	■	■	■	■	■	■	■	■
Measurement Estimation & Errors							■	■	■	■	■	■	■	■	■	■
Constructions w/ Straightedge & Compass							■	■	■	■	■	■	■	■	■	■
3-D Geometry							■	■	■	■	■	■	■	■	■	■
Congruence & Similarity							■	■	■	■	■	■	■	■	■	■
Rational Numbers & Their Properties							■	■	■	■	■	■	■	■	■	■
Patterns, Relations & Functions							■	■	■	■	■	■	■	■	■	■
Slope & Trigonometry							■	■	■	■	■	■	■	■	■	■

Figure 2. The Shape of Mathematics Standards in A+ Countries.

Figure 2 displays composites for mathematics by topic and grade level. The upper triangular shape of the data for A+ countries on the left side of the table highlights a curriculum that focuses on a small number of topics that provides a continuous pattern of mathematical complexity. Arithmetic is the major focus for Grades 1-4 with more advanced mathematics topics beginning in Grades 7 and 8. The right side of the table displays topics covered and the duration in the United States. The coherence of the major topics is apparent, but the major difference is the duration of the coverage of topics. The average duration topics in state standards were covered almost twice as long as the A+ countries.

Ginsburg, Leinwand, Anstrom, and Pollock (2005) conducted a study for the American Institute of Research to compare state mathematics standards with Singapore

mathematics standards. Results revealed that the state mathematics standards for Grades 1-6 have far more topics than the Singapore standards. Every state included more topics per grade than the Singapore standards. “At the low end of the range, North Carolina teaches about 20 percent more topics per grade. At the high end, Florida’s framework covers 160 percent more topics than Singapore’s” (Ginsburg et al., 2005, p. 31).

Instruction in the United States tends to focus on many concepts instead of bundling high level thinking skills that build conceptual understanding and problem-solving skills (Daro, 2006). “When instruction focuses on a small number of key areas of emphasis, students gain extended experience with core concepts and skills. Such experience can facilitate deep understanding, mathematical fluency, and an ability to generalize” (NCTM, 2006, p. 14). Singapore is the leading performing nation of standardized tests for the past 15 years (Gonzales et al., 2008; TIMSS, 2015). Singapore Mathematics insists that elementary student achievement occurs when mathematics teachers engage their students in problem-solving activities. Mathematical problem-solving is the main concept in the Singapore Mathematical Framework as indicated in Figure 3.

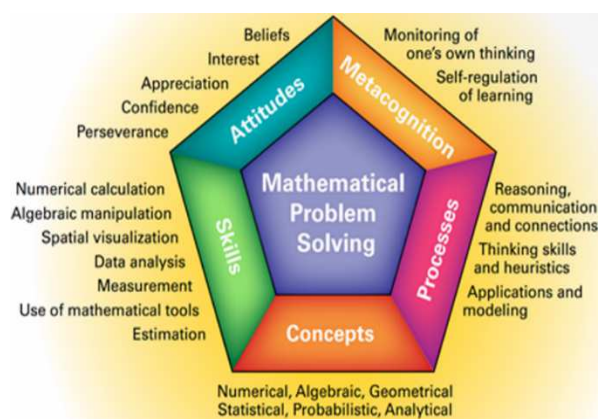


Figure 3. Framework of the Singapore Mathematics Curriculum.

Singapore Mathematics focuses on fewer topics in greater depth, building conceptual understanding, focus on mastery of concepts, and building student's metacognition (Educational Research Institute of America, 2010). Published by Marshall Cavendish (2013) in partnership with Houghton Mifflin Harcourt, *Math in Focus* is the United States revised version of the Singapore Mathematics program. Based on concepts of Bruner's (1966) book *Toward a Theory of Instruction*, Singapore Mathematics modified Bruner's most popular concept, the Enactive-Iconic-Symbolic learning theory of representation. The learning theory is known in Singapore Mathematics as Concrete-Representational-Abstract (CRA; Bruner 1966; Thornburgh, 2004).

In the concrete stage, the teacher begins instruction by modeling each mathematical concept with concrete materials (e.g., red and yellow chips, cubes, base ten blocks, pattern blocks, fraction bars, and geometric figures). In this stage, the teacher transforms the concrete model into a representational (semi-concrete) level, which may involve drawing pictures; using circles, dots, and tallies; or using stamps to imprint pictures for counting. At the Abstract stage, the teacher models the mathematics concept at a symbolic level, using only numbers, notation, and mathematical symbols to represent the number of circles or groups of circles. The teacher uses operation symbols ($+$, $-$, \times , \div) to indicate addition, multiplication, or division. (Thornburgh, 2004, p. 1)

CRA allows students to conceptually learn mathematics instead of rote memorization and learning of rules. A study conducted by the Educational Research Institute of America (2010) investigated the effects of *Math in Focus* over the course of a school year. The results demonstrated a significant improvement on state standardized mathematics

assessments when compared to a control group of students in the same school district.

According to Instructional Materials Evaluation Tool (2013), *Math in Focus* for Grades K-5 meets the four “non-negotiable” criteria to be considered CCSSI aligned (p. 1).

According to Schmidt (2008),

In the early grades, top-achieving countries usually cover about four to six topics related to basic numeracy, measurement, and arithmetic operations. That’s all. In contrast, in the U.S., state and district standards, as well as textbooks, often cram 20 topics in the first and second grades. That’s much more than any child could absorb. (pp. 22-23)

Successful implementation of CCSS requires a focus on the major works of the grades (Achieve the Core, 2012; CCSSI, 2010). Some clusters are given greater emphasis “based on the depth of the ideas, the time that they take to master, and/or their importance to future mathematics or the demands of college and career readiness” (Achieve the Core, 2018, p. 8). For example, Figure 4 displays the major works of the grade for Kindergarten through eighth grade.

Grades	Major Works of the Grade
K–2	Addition and subtraction - concepts, skills, and problem solving; and place value
3–5	Multiplication and division of whole numbers and fractions - concepts, skills, and problem solving
6	Ratios and proportional relationships; early expressions and equations
7	Ratios and proportional relationships; arithmetic of rational numbers
8	Linear algebra and linear function

Figure 4. Summary of the Major Work in Grades K-8 Common Core Mathematics Standards.

Coherence. According to Achieve the Core (2012), the second shift of CCSSM is coherence. Mathematical coherence is “Thinking across grades, and link to major topics within grades” (Achieve the Core, 2012, p. 1). CCSSM are designed to provide progression from grade to grade and connect across grades to build new understandings based on prior skills. Each standard is written to be a building block from a previous standard (Achieve the Core, 2012; CCSSI, 2010).

In their study, Valverde and Schmidt (2000) found that focus and coherence were present in A+ countries: Belgium, Czech Republic, Hong Kong, Japan, Korea, and Singapore mathematics curriculum. In an international benchmark, Schmidt et al. (2002) compared coherence of standards in the United States to standards used by A+ countries. The results revealed that the mathematics topics in the A+ countries were coherent and the United States curriculum was incoherent. In a later study, Schmidt, Wang, and McKnight (2005) discovered corresponding results. A+ countries implemented a more coherent mathematics curriculum where topics progressively increased in complexity. An additional study by Schmidt and Houang (2012) examined CCSSM to determine the level of focus and coherence as defined in A+ countries. Results echoed the previous finding that CCSSM exhibited focus and coherence when compared to the A+ model (Gewertz, 2012; Schmidt & Houang, 2012).

Leo and Cogshall (2013) found that there are mathematical instructional practices aligned with the Common Core for the process of establishing coherence. The instructional practices

are just one starting point for the process of creating coherence. States may choose to convene stakeholders to determine their own set of Common Core-

aligned instructional practices, or they may use a similar set of aligned practices from another organization such as Student Achievement Partners or CCSSO's Interstate Teacher Assessment and Support Consortium. (Leo & Coggshall, 2013, p. 8)

Building on Principles and Standards for School Mathematics (NCTM, 2000), the NCTM released Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence. The writing committee was composed of nine members with at least one teacher from prekindergarten through Grade 2, Grades 3-5, Grades 6-8, and the postsecondary level. The focal points were created based on various states' and countries' curricula in a quest to develop a more coherent mathematics curriculum in the United States (NCTM, 2006).

For inclusion in Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics, a focal point had to pass three rigorous tests: Is it mathematically important, both for further study in mathematics and for use in applications in and outside of school?; Does it "fit" with what is known about learning mathematics?; Does it connect logically with the mathematics in earlier and later grade levels? (NCTM, 2006, p. 14)

Schmidt et al. (2002) stated that assessing the coherence of a set of standards is more difficult than assessing their focus. Standards and curricula are coherent if they are articulated over time as a sequence of topics and performances that are logical and reflect, where appropriate, the sequential or hierarchical nature of the disciplinary content from which the subject matter derives. That is, what and how students are taught should reflect not only the topics that fall within a certain academic

discipline, but also the key ideas that determine how knowledge is organized and generated within that discipline. This implies that to be coherent, a set of content standards must evolve from particulars (e.g., the meaning and operations of whole numbers, including simple math facts and routine computational procedures associated with whole numbers and fractions) to deeper structures inherent in the discipline. These deeper structures then serve as a means for connecting the particulars (such as an understanding of the rational number system and its properties. (Schmidt et al., 2002, p. 9)

Rigor. The third shift of CCSSM is rigor (Achieve the Core, 2012). Depending on context and practice, rigor has a myriad of definitions (Blackburn, 2013; Bower & Powers, 2009). As defined by Bower and Powers (2009),

rigor is how the standard curriculum is delivered within the classroom to ensure students are not only successful on standardized assessments but also able to apply this knowledge to new situations both within the classroom and in the real world. (p. 7)

Blackburn (2013) suggested,

Rigor is more than what you teach and what standards you cover; it's how you teach and how students show you they understand. True rigor is creating an environment in which each student is expected to learn at high levels, each student is supported so he or she can learn at high levels, and each student demonstrates learning at high levels. (p. 10)

Hess, Carlock, Jones, and Walkup (2009) defined rigor as “complex thinking and application of knowledge” (p. 8) that focused on building conceptual understanding.

Boston and Wolf (2006) echoed this definition. According to Boston and Wolf, rigorous instruction is demonstrated in a classroom when students understand and master major concepts, solve real-world problems on a regular basis, and use higher order thinking skills to construct and communicate their explanations (Bower & Powers, 2009; CCSS, 2010; Marzano & Toth, 2014). Figure 5 identifies 13 essential teaching strategies required in rigorous instruction (Marzano & Toth, 2014). These strategies should be implemented as a unit and require a shift from traditional pedagogy to career and college readiness standards. Although the “strategies are listed in a linear fashion, they may be used in any phase of instruction, from building foundational content to deepening content to utilizing knowledge and skills to engage in complex tasks” (Marzano & Toth, 2014, p. 1).

Identifying Critical Content
Previewing New Content
Organizing Students to Interact with Content
Helping Students Process Content
Helping Students Elaborate on Content
Helping Students Record and Represent Knowledge
Managing Response Rates with Tiered Questioning Techniques
Reviewing Content
Helping Students Practice Skills, Strategies, and Processes
Helping Students Examine Similarities and Differences
Helping Students Examine Their Reasoning
Helping Students Revise Knowledge
Helping Students Engage in Cognitively Complex Tasks

Figure 5. 13 Essential Teaching Strategies to Teach Rigor.

“Rigor in mathematics is not defined by making math harder or by introducing topics at earlier grades, as is commonly assumed” (Alberti, 2012, p. 27). Although

teachers facilitate instruction, mathematical rigor is what students are actively doing to increase their learning (Hull, Balka, & Miles, 2013). According to Hull et al. (2013), rigor in the mathematics classroom should be defined in two ways: mathematical content rigor and mathematical instructional rigor.

Mathematical content rigor is the depth of interconnecting concepts and the breadth of supporting skills students are expected to know and understand.

Mathematical instructional rigor is the effective, ongoing interaction between teacher instruction and student reasoning and thinking about concepts, skills, and challenging task that results in a conscious, connected, and transferable body of valuable knowledge for every student. (Hull et al., 2013, p. 1)

CCSSI (2017) referred to mathematical rigor as the “deep, authentic command of mathematical concepts, not making math harder or introducing topics at earlier grades” (p. 1). The rigorous instruction requires mathematics to be taught in a way that builds student conceptual understanding, their procedural skill and fluency, and their ability to apply what they know to solve real-world, problem-solving situations (Achieve the Core, 2012; Alberti, 2012; CCSSI, 2017).

Assessing the level of rigor in a classroom has been as complicated as defining it (Wagner, 2006). Jones’s (2010) Framework for Rigor outlined in Figure 6 has been used by many educators to examine the level of rigor in mathematical assessment, curriculum, and instruction (Keasler & Headley, 2017).

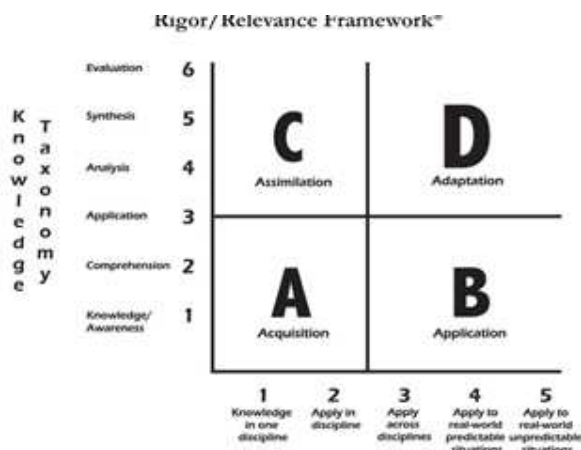


Figure 6. Rigor/Relevance Framework for Curriculum, Instruction, and Assessment.

An example of Quadrant A is to select the computational operation to solve word problems. This task is low in relevance and rigor. In Quadrant B, relevance is high but rigor is low. Classroom task for Quadrant B would be to calculate the percent of daily requirements met through a typical school lunch. An example of Quadrant C, graphing the perimeters and areas of squares of different sizes demonstrates high rigor but relevance to real-world problems are low. In Quadrant D, relevance and rigor are high. Planning a large school event and calculating resources (food, decorations, etc.) needed and costs would be an example of a task that demonstrates Quadrant D (Jones, 2010; Keasler & Headley, 2017).

Hess et al. (2009) combined Bloom's Revised Taxonomy and Webb's Depth of Knowledge model to devise a Cognitive Rigor Matrix (see Hess, 2013; Appendix B) to analyze levels of rigor and depth of cognitive challenge in both formative and summative assessment. The Standards Company, LLC (2008) conducted a study to evaluate Nevada and Oklahoma "enacted curriculum" (p. 7). In their study, they examined over 200,000 student formative and summative work samples using the Cognitive Rigor Matrix.

“Cognitive rigor—higher-order thinking skills and sophisticated projects are essential elements of academic rigor” (The Standards Company, LLC, 2008, p. 6). As indicated in the dark sections of Figures 7-9, results revealed that the majority of the third-, fourth-, and fifth-grade assignments demonstrated low levels of depth of knowledge as well as low levels of Bloom’s Taxonomy. While 1% of the Grade 3 assignments demonstrated high levels of Bloom’s Taxonomy, they still possess low levels of depth of knowledge. On the other hand, 1% of assignments for fourth- and fifth-grade students demonstrated high levels of Bloom’s Taxonomy as well as high levels of depth of knowledge.

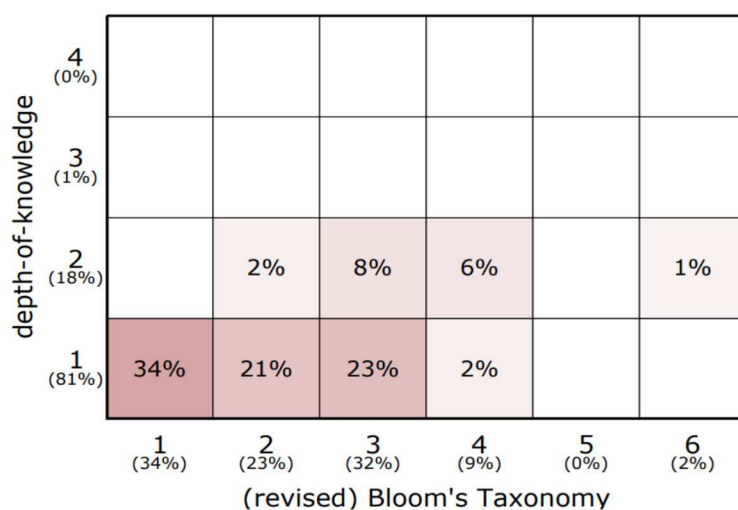


Figure 7. The Cognitive Rigor for Third Grade Mathematics Assignments.

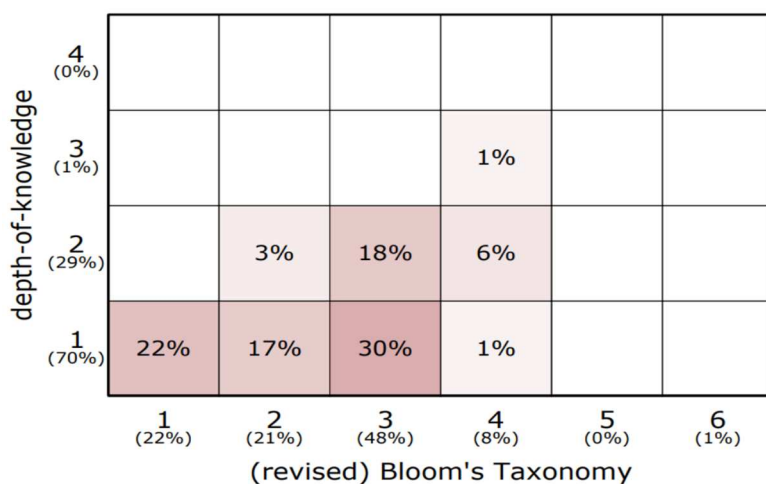


Figure 8. The Cognitive Rigor for Fourth Grade Mathematics Assignments.

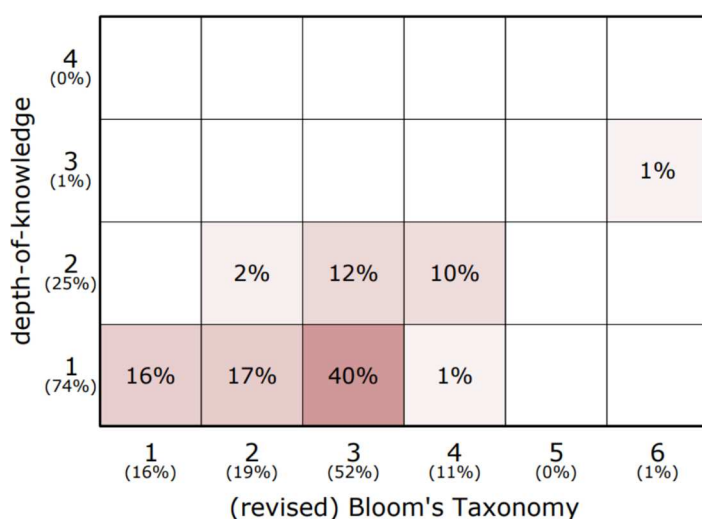


Figure 9. The Cognitive Rigor for Fifth Grade Mathematics Assignments.

Studies of the mathematical classroom have been examined to identify strategies to successfully implement the shift to academic rigor. CCSSI (2010) conducted a content analysis of CCSSM using the content frameworks and the Surveys of Enacted Curriculum methodology. The Surveys of Enacted Curriculum is nationally recognized for its ability to calculate alignment using “topographical maps in which topics are

displayed like lines of latitude and cognitive demands like lines of longitude to display alignment and misalignment” (Porter, McMaken, Hwang, & Yang, 2011, p. 105). The categories of cognitive demands analyzed were memorization, perform procedures, demonstrate understanding conjecture, generalize, and prove solve nonroutine problems. The results revealed that in comparison to state standards for Grades 3-6, the Common Core standards had shifted toward a greater emphasis on higher order cognitive demand, demonstrating understanding and performance of procedures instead of rote memorization. The study also revealed that state standards were inconsistent from state to state, making some highly correlated and others low correlated (Porter et al. 2011).

Kane et al. (2016) conducted a survey of states that fully implemented CCSS. Thirty-five of 46 states indicated that CCSSM increased rigor and would consequently improve student achievement. Cronin, Dahlin, Adkins, and Kingsbury (2007) concluded in the Fordham Institute that Common Core standards are more clearly and rigorous than 39 state standards in mathematics. According to Marzano and Toth (2014), students are successful with CCSSM if they develop the ability to collaborate, analyze, synthesize, make conjectures, and hypothesize in the mathematics classroom.

In their research at the Learning Sciences Marzano Center, Marzano and Toth (2014) collected over two million data points where they observed classroom instructional strategies with a focus on rigor. The results suggest that the majority of teachers implemented classroom strategies based on lower levels of Bloom, Englehart, Furst, Hill, and Krathwohl’s (1956), Webb’s (2002), and Marzano’s (2001) taxonomies of educational frameworks. “It is our conclusion that instruction focused on achieving rigor is rare. The lack of such instruction amounts to a crisis if we expect students to

meet the standards that have been put in place for them” (Marzano & Toth, 2014, p. 15). Due to the implementation of CCSS, teachers have to expand their instructional practices to prepare students for career and college readiness across all three aspects of rigor (Achieve the Core, 2012). In addition to the three shifts of focus, coherence, and rigor, CCSSM includes eight standards of mathematical practices (CCSSI, 2017; Engage NY, 2014; Great Minds, 2016; Lyons, 2012).

The Eight Standards for Mathematical Practices. The last major significant shift of CCSSM include the Standards for Mathematical Practices which “describe varieties of expertise that mathematics educators at all levels should seek to develop in their students” (CCSSI, 2018, p. 1).

The eight Standards of Mathematical Practices actively engage students while learning mathematics (Confrey & Krupa, 2010) and illustrate “varieties of expertise that educators at all levels should seek to develop in their students” (Kuchey & Flick, 2011, p. 6). They are intertwined as well and should be implemented simultaneously with the math content standards (Rothman, 2012). The Standards of Mathematical Practices are as follows:

Make sense of problems and persevere in solving them; Reason abstractly and quantitatively; Construct viable arguments and critique the reasoning of others; Model with mathematics; Use appropriate tools strategically; Attend to precision (communication with others using clear definitions in discussion and in their own reasoning); Look for and make use of structure; Look for and express regularity in repeated reasoning. (McCallum, 2011, p. 2)

Boston and Wolf (2006) examined research on math modeling, one of the eight

math practice standards. Three hundred sixty-four K-12 teachers in eight Southern California school districts completed open-ended questions relating to their understanding of mathematical modeling, willingness to change practice, and concerns about successful implementation of math modeling. Although the majority of participants were willing to change their practice and believed that math modeling would aid in student achievement, they indicated that professional development is needed to successfully implement the practice standard.

Huang, Barlow, and Haupt's (2017) study examined how teachers improve problem-solving through Lesson Study. Three Lesson Study groups developed an algebra task, implemented the task, and then effectively orchestrated student solutions. Data were collected through videotaped lessons, lesson plans, debriefing meetings, and surveys. Survey results, lessons, and lesson plans revealed that after participating in the sessions, teachers were better prepared to launch, teach problem-solving strategies, and solicit student solutions to tasks. During the debriefing meetings, teachers agreed that feedback from experts played a critical role in changing implementation of core instructional practices. Subsequently, students obtained the ability to solve mathematical tasks more efficiently (Huang et al., 2017).

Perry et al. (2015) conducted a large scale K-8 study on eight California school districts that participated in "Math in Common" (p. 1). Math in Common is a 5-year initiative to aid in the successful implementation of the CCSSM. "Districts are part of a community of practice in which they share their progress and successes, as well as their challenges and lessons learned about supports needed for CCSS-M implementation" (Perry et al., 2015, p. 1). The goal of this research was to understand teacher, school

administrator, and building administrator perspectives on the implementation of CCSSM. Perry et al. categorized their findings into the following categories: professional learning, implementation, curriculum and instruction, preparedness to implement CCSSM, and participant background.

Sixty percent of K-5 respondents agreed that the CCSSM is having a positive effect on my students' mathematics learning, 58% agreed that the CCSSM is having a positive effect on their mathematics teaching and 78% felt that they possess adequate content knowledge. (Perry et al., 2015, pp. 11-12)

to facilitate learning for their students. Compared to what teachers reported for mathematics content knowledge, there was skepticism about their preparation to support their students in achieving CCSSM. Sixty-four percent felt confident in their ability to support student use of the Standards for Mathematical Practice and 57% agreed that mathematics concepts and depth of knowledge were prioritized for their grade. As a result of the research, two of the school districts employed strategies to support CCSSM implementation efforts. The strategies were created based on data collected on the level of implementation of the Standards for Mathematical Practice and CCSSM content into their daily classroom practice. One district used a classroom walk-through tool to develop four understandings of CCSSM implementation:

(1) high-quality instruction, (2) student productive struggle and persistence, (3) effective collaborative conversations, and (4) formative assessment. A second district chose the SMP, mathematical rigor, and several instructional practices as the focus of CCSSM implementation. (Perry et al., 2015, p. 12)

The eight Standards of Mathematical Practices were derived from the Process

Standards from NCTM (2000) and the strands of mathematical proficiency, outlined in Figure 10 (National Research Council, 2001).

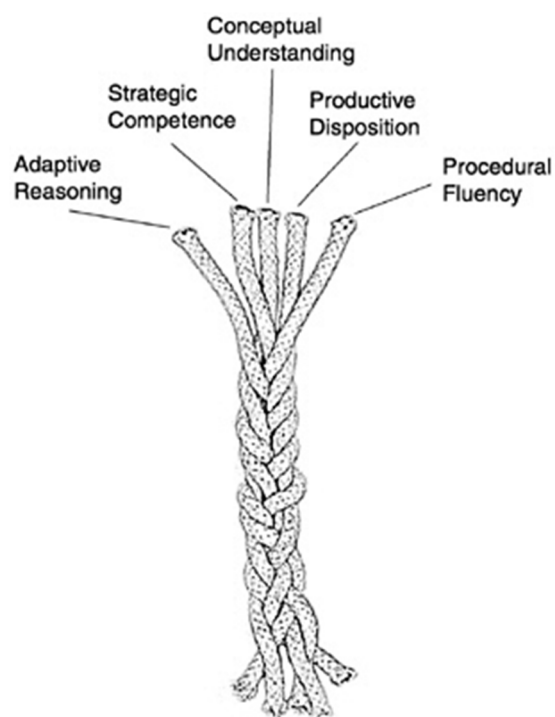


Figure 10. The Intertwined Strands of Mathematical Proficiency.

According to the National Research Council (2001), the five strands “are interwoven and interdependent in the development of proficiency in mathematics” (p. 137). The tightly interwoven rope suggests that individual strands implemented in isolation will not develop mathematical proficiency. Similar to the mathematical practice, the five strands should be embedded in daily mathematical challenges to prepare students for future success in college and careers (Kilpatrick, Swafford, & Findell, 2001). Teachers have to offer opportunities that result in success for every student and possess the belief that they can teach common core mathematics effectively to every student (Bandura, 1977; Tschannen-Moran & Woolfolk Hoy, 2001). Believing in one’s ability to influence the learning of all students is teacher self-efficacy (Bandura 1977).

Teacher Self-Efficacy

The influence of self-efficacy has been facilitated by Bandura's (1977) and Rotter's (1954) study. Self-efficacy is one's perception of their ability to achieve a goal (Bandura, 1977). It is the belief in "one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). According to Bandura (1986), if teachers do not believe they can accomplish a task, they are more likely to give up and not complete the task. Tschannen-Moran and Woolfolk Hoy (2001) defined teacher self-efficacy as "a judgment about 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. 1). The belief that every child can learn and a teacher's belief in their own skills or abilities develop their level of efficacy.

Bandura's (1997) study suggests that there are four main sources of self-efficacy: enactive mastery, vicarious modeling, verbal persuasion, and physiological and emotional arousal. Enactive mastery is the most important source of increasing self-efficacy (Bandura, 1997). Through the repeated practices, teachers gain relevant experiences and subsequently gain more confidence (Briley, 2012; Smith, 2010). According to Bandura (1977, 1997), vicarious modeling, the second source of increasing self-efficacy, is accomplished by observing the successes of other colleagues similar to them. Vicarious modeling helps the teacher visualize success, which enables them to accomplish a task. Verbal persuasion helps increase self-efficacy when others build one's confidence through words of encouragement and persuasion. "Verbal persuasion alone may be limited in its power to create enduring increases in perceived efficacy, but it can bolster self-change if the positive appraisal is within realistic bounds" (Bandura, 1997, p. 101).

Physiological and emotional arousal is the last source of increasing self-efficacy.

Physiological and emotional arousal is the way one perceives one's anxiety level in different situations. Perception determined by physiological reactions can influence efficacy beliefs (Redmond, 2010). While stress and fear can negatively affect self-efficacy, positive emotions increase one's self-efficacy and lead to higher performance (Bandura, 1997; Redmond, 2010).

Tournaki and Podell's (2005) study "examined how the interaction between student and teacher characteristics affects teachers' predictions of students' academic and social success" (Mojavezi & Tamiz, 2012, p. 484). In their study, 384 general education teachers responded to possible case studies in which student characteristics were "manipulated experimentally" (Tournaki & Podell, 2005, p. 494). Results from a 16-item teacher efficacy scale suggest that teachers with low self-efficacy made negative predictions for their students' success based on student characteristics and motivation. Teachers demonstrating high self-efficacy adjusted their predictions when student characteristics changed. All participants tolerated inattentive and aggressive behaviors if students demonstrated characteristics of being friendly.

Additionally, a study by Gibson and Dembo (1984) investigated relationships between teacher efficacy and behavior in the classroom. Of the 90 teachers surveyed, eight demonstrated low and high efficacy were observed. Teachers with high efficacy spent more time planning, less time on whole group instruction, and more time monitoring student work than teachers with low self-efficacy. Teachers with low efficacy were more critical and less persistent with struggling students. Teachers who possess high self-efficacy believe they can control the outcome of the situation.

Mathematics Teaching Self-Efficacy

Mathematics teaching self-efficacy is defined as a teacher's belief that they can teach others mathematics (Kahle, 2008; Swars, 2004). Studies have suggested relationships among teacher levels of self-efficacy, levels of teacher anxiety (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006), instructional practices (Wertheim & Leyser, 2002), and student achievement (Alrefaei, 2015; Armor et al., 1976; Ashton & Webb, 1986; Gallagher, 2002; Guskey, 1982; Harris, 2010).

Ashton and Webb's (1986) study was one of the first attempts to investigate mathematics teaching efficacy. Their study indicated that teacher efficacy beliefs "can be expected to have different relationships to different subject matter, depending on teachers' beliefs about the subject being taught and the students in the classroom" (Ashton & Webb, 1986, p. 139). Participants completed the Webb efficacy scale (Ashton & Webb, 1986), Ashton Vignettes (Ashton, Buhr, & Crocker, 1984), and the two RAND items (Armor et al., 1976) to measure teacher efficacy to assess teacher sense of mathematics teaching efficacy. Developed by Ashton et al. (1984), the Ashton Vignettes assess if teacher efficacy is context specific. The vignettes describe situations teachers may encounter and ask teachers to judge how they would perform (Ashton et al., 1984). The sum of the two RAND items was called teacher efficacy. In the RAND research, teachers respond to their agreement that they control the consequences of a teacher as well as student motivation and learning. The Webb efficacy scale extends the measure of teacher efficacy to correspond to social cognitive theory concepts. Based on the two RAND items, general efficacy correlated with an increase in mathematics achievement, but personal efficacy did not. The study suggested a positive relationship between

teacher's mathematics teaching efficacy and their student's mathematics test scores. Teachers with high mathematics self-efficacy believe they can be successful when learning and teaching mathematics, while teachers with low mathematics self-efficacy have lower mathematics performance (Hackett & Betz, 1989).

Bates, Latham, and Kim (2011) examined 89 teachers' mathematics self-efficacy and mathematics teacher efficacy and compared them to their mathematical performance using the Mathematics Self-Efficacy Scale (MSES), the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), and the Illinois Certification Testing System (ICTS). Findings suggest a positive correlation between mathematics performance, mathematics self-efficacy, and higher mathematics teacher efficacy. The higher the participants scored on the ICTS, positively correlated with their score on the MSES and MTEBI.

Briley's (2012) study consisted of three surveys to measure mathematics teacher efficacy, mathematics self-efficacy, and mathematical beliefs. The participants were 95 elementary preservice teachers enrolled in four sections of Mathematics for the Elementary School Teacher. Mathematics for the Elementary School Teacher is a required mathematics course for elementary preservice teachers with an emphasis on upper elementary mathematics concepts. These classes are instructed by a combination of lecture and hands-on activities. The MTEBI, consisting of 21 items which are organized into two subscales: the Personal Mathematics Teaching Efficacy (PMTE) subscale and the Mathematics Teaching Outcome Expectancy (MTOE) subscale (Enochs, Smith, & Huinker, 2000), was administered to measure mathematics teaching efficacy. The problems subscale of the Mathematics Self-Efficacy Scale-Revised (MSES-R), consisting of 18 items (Pajares & Kranzler, 1995), assessed mathematics self-efficacy,

and the Conceptions of Mathematics Inventory-Revised (CMI-R; Briley, Thompson, & Iran-Nejad, 2009), was administered to measure mathematical belief.

The research hypotheses examined were as follows: Mathematical beliefs, mathematics self-efficacy, and mathematics teaching efficacy are positively related; Mathematical beliefs and mathematics self-efficacy are positive predictors of mathematics teaching efficacy; Mathematical beliefs have a significant effect on mathematics teaching efficacy; and Mathematical beliefs have a significant effect on mathematics self-efficacy. (Briley, 2012, p. 4)

Findings provide evidence for positive relationships between the teachers' mathematical belief, self-efficacy, and mathematics teaching efficacy. The participants agreed with the PMTE items and agreed less with the MTOE items on the MTEBI. Although the participants had limited mathematics teaching experience, they had moderately strong beliefs in their capabilities to teach mathematics effectively. Based on the problems subscale mean, teachers who have strong beliefs in their ability to teach mathematics effectively possess higher confidence in solving mathematics problems. Both mathematical beliefs and mathematics self-efficacy were statistically significant positive predictors of mathematics teaching efficacy (Bates et al., 2011; Briley, 2012).

Similarly, Smith (2010) conducted a quantitative study to determine the mathematics anxieties, mathematical self-efficacies, mathematical teaching self-efficacies, and instructional practices of certified elementary teachers. The study also examined if elementary teachers' mathematics anxiety, mathematical self-efficacy, and mathematical teaching self-efficacy have an effect on their instructional practices in mathematics. Data were collected through the abbreviated Mathematics Anxiety Scale

(Hopko, Mahadevan, Bare, & Hunt, 2003), the Mathematics Teaching and Mathematics Self-Efficacy Survey (Kahle, 2008), and the Patterns of Adaptive Learning Survey (Midgley et al., 2000). Results specified a substantial relationship between mathematical teaching self-efficacy and performance-based instruction. Although their findings revealed relationships between mathematical teaching self-efficacy and three of the four PALS subscales and mathematics teaching efficacy with two of the four PALS subscales, no relationship was found with mathematics anxiety and mathematics self-efficacy. On the MTMSE, teachers demonstrated an overall high sense of mathematical self-efficacy and mathematical teaching self-efficacy. Teachers' "mathematical teaching self-efficacy was positively related to mastery instruction (the kind of instruction identified as being most effective); which supports previous research showing that highly efficacious teachers implement effective instructional practices" (Smith, 2010, p, 168). The data revealed inconsistencies with the impact mathematical teaching efficacy has on teachers' instructional practices. "Teachers reported a high sense of general mathematical teaching self-efficacy, which was said to increase their mastery goal structure for students" (Smith, 2010, p. 144). An increase in the same self-efficacy did not always increase their performance goal structure for students (Smith, 2010).

Swars's (2004) study further addressed mathematics teaching self-efficacy. He conducted a study of 26 elementary teachers with varying levels of mathematics teacher efficacy. The investigation examined teacher perceptions of their skills and effectiveness to teach mathematics. The MTEBI was administered to all participants. The two teachers who scored the highest and the lowest were then interviewed. The study suggests that the teachers with the lowest level of mathematics teacher efficacy

encountered negative experiences with mathematics in elementary school themselves.

Studies also found a positive as well as negative correlation (Bursal & Paznokas, 2006; Swars et al., 2006) between mathematics teaching self-efficacy and anxiety. Swars et al.'s (2006) mixed-method study of 28 elementary preservice teachers examined the relationship between mathematics teacher efficacy and their level of mathematics anxiety. The participants completed the MTEBI and the Mathematics Anxiety Rating Scale (MARS). Results revealed a negative relationship between mathematics teacher efficacy and mathematics anxiety. Participants with high levels of mathematics efficacy had low levels of anxiety. Interviews revealed that teachers with low levels of anxiety had a negative experience while in school themselves. Although all of the participants were confident to teach mathematics, only the teachers demonstrating low anxiety felt they could teach mathematics effectively to struggling students.

Closely related to teachers' expectations is their sense of efficacy, the feeling that they are effective in helping students learn. Successful teachers, not only expect their students to succeed, but also see themselves as capable of motivating and instructing students effectively. Less successful teachers lack confidence in themselves as instructors. (National Research Council, 2001, p. 338)

Teachers who possess the belief that they can teach all students are more successful (Henson, 2001).

Measuring Teacher Self-Efficacy

There are over 25 years of research regarding the measurement of teacher self-efficacy (Gavora, 2010). According to Tschannen-Moran and Woolfolk Hoy (2001) and Tschannen-Moran, Woolfolk Hoy, and Hoy (1998), there have been numerous

investigations on the concept of self-efficacy. Research has been based on Rotter's social learning theory's external and internal locus of control or the work of Bandura's social cognitive theory (Tschannen-Moran et al., 1998). Instruments used to measure self-efficacy were based on one of these theoretical frameworks. Although the study of self-efficacy and self-efficacy scales have "borne much fruit in the field of education.... Researchers have had difficulty developing a measurement tool to capture it" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 271).

Instruments Related to Rotter's Social Learning Theory

Based on Rotter's (1966) work on Social Learning Theory, the first instruments to measure self-efficacy were created by the RAND Corporation in 1976.

Rotter's (1966) locus of control. The belief that you can control the outcome of a situation is called locus of control. Teacher self-efficacy originated by RAND researchers as an extension of Rotter's (1966) theoretical concept of locus of control. Locus of control is a cognitive theory that addresses people beliefs on how well they control certain situations and the experiences that affect the outcome (Rotter, 1954). Locus of control is categorized on a scale from internal to external. Internal locus of control means that one has intrinsic control over a situation (Rotter, 1990), while external locus of control indicates that outside factors have more control of the situation (Rotter, 1990). Most people who have high self-efficacy tend to have an internal locus of control. Failure sometimes contributes to an external locus of control in people who have high self-efficacy.

The RAND research. The RAND researchers added two sense of self-efficacy items to their reading programs assessment to measure the first sense of teacher efficacy.

The two items based on Rotter's (1966) study revealed a strong, positive correlation of teacher self-efficacy to student performance, performance goals, and other positive educational outcomes. Item one was, "when it comes right down to it, a teacher really can't do much—most of a student's motivation and performance depends on his or her home environment" (Armor et al., 1976, p. 24). Item two was, "If I try really hard, I can get through to even the most difficult or unmotivated students" (Armor et al., 1976, p. 24). RAND researchers also investigated factors that teachers believe could control their ability to teach their students. If teachers believe they could control their actions, their teaching efforts were internal. Teachers who agreed that environmental factors impact student learning have external control. Participants of the RAND study were asked to indicate their level of agreement with the two questions on their sense of self-efficacy. The sum of the two items was called teacher efficacy.

Armor et al.'s (1976) teacher efficacy study. Armor et al. contributed teacher personal beliefs and attitudes as well as demographic characteristics to the RAND research. Additionally, Armor et al.'s study examined four sources of influence on reading growth within the school's control: teacher attributes that shape the instructional process, the classroom setting, instructional methods, and the implementation of reading programs. Similar to RAND research, Armor et al.'s study also used Rotter's theoretical framework of locus of control and predated Bandura's social cognitive theory (Tschannen-Moran et al., 1998). Concerned about the reliability of the two-item scale, researchers attempted to create a more comprehensive assessment to measure self-efficacy.

Rose and Medway's (1981) teacher locus of control instrument. Rose and

Medway (1981) created the teacher locus of control scale. The 28-item questionnaire asked teachers to identify reasons for student successes and failures “between two competing explanations for the situations described” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 786). “For each success, one explanation attributes the positive outcome internally to the teacher (I+).... For each failure situation, one explanation gives an internal teacher attribution (I-) while the other blames external factors” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 786).

Guskey’s (1982) responsibility for student achievement. Guskey (1982) developed a scale to measure the relationship between teacher efficacy and responsibility for student achievement by using the two RAND items. Guskey’s (1982) studies reveal positive correlations between student success and failures and teacher self-efficacy. The study also revealed that highly efficacious teachers demonstrated positive attitudes when implementing new instructional practices to improve learning for students.

Instruments Related to Bandura’s Social Cognitive Theory

Over the years, researchers have encountered various problems relating to the measurement of self-efficacy (Bandura, 1986; Multon, Brown, & Lent, 1991). Previous quantitative studies based on Rotter’s (1966) research provided valuable insight on teacher self-efficacy. Many experienced high teacher efficacies as preservice teachers (Bandura, 1986; Woolfolk Hoy & Hoy, 2003). Although studies provided critical information on the development of teacher self-efficacy, the question of why was often left unanswered (Woolfolk Hoy & Hoy, 2003). Bandura (1997) warned researchers that “self-efficacy beliefs should be measured in terms of particularized judgments of capability that may vary across realms of activity, different levels of task demands within

a given activity domain, and under different situational circumstances” (p. 6). Self-efficacy is the premonition and competence a person possesses when certain situations arise. Bandura (1997) defined perceived self-efficacy as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (p. 3). Unlike social learning theory, social cognitive theory concludes an outcome expectation, different from efficacy expectation. Outcome expectancy is an individual’s estimate of the consequences of an action, while efficacy expectations is an individual’s belief that a person can succeed at a given task (Bandura, 1986).

The Teacher Efficacy Scale (TES) developed by Gibson and Dembo (1984) was the first scale to specifically measure teacher self-efficacy. The scale is known as the standard instrument to measure teacher efficacy for in-service and preservice teachers (Gavora, 2010). The scale has also inspired the development of content-specific scales for teaching mathematics and other subjects. Two hundred eight elementary teachers from 13 schools participated in a two-phase study where they completed a 30-item measure on a 6-point Likert scale ranging from strongly agree to strongly disagree (Gibson & Dembo, 1984). Findings from the study revealed that teachers with high efficacy were more likely to implement small group instruction opposed to the whole group and were more likely to guide and help students persist to the correct answer (Gibson & Dembo, 1984).

Gibson and Dembo (1984) later developed a 16-item form and Woolfolk Hoy and Hoy (2003) developed a 10-item form. The 10-item teacher efficacy form consisted of five personal and five general teaching efficacy items. Similar to the original 30-item form, reliabilities were found within the range of alpha .77 for personal teacher efficacy

(PTE) and .72 for general teacher efficacy (GTE). The three forms have been widely used for numerous research “in a variety of school environments and at diverse types of schools, administered to in-service teachers who taught across a variety of school subjects, and used with pre-service teachers” (Gavorad, 2010, p. 4). The TES analyzes two domains, PTE and GTE, which are based on Bandura’s (1977) theoretical model of self-efficacy. PTE ($\alpha=.75$) assessed self-efficacy and GTE ($\alpha=.79$) assessed outcome expectancy (Gavora, 2010; Hoy, 2000). PTE refers to a teacher’s belief in oneself to influence student learning (Tschannen-Moran et al., 1998) while GTE is a teacher’s expectations to influence learning (Ashton & Webb, 1986).

Bandura’s Teacher Self-Efficacy Scale. Bandura (1997) developed his own Teacher Self-Efficacy Scale in an attempt to find the most efficient measure to assess teacher efficacy. “This measure attempted to provide a multifaceted picture of teachers’ efficacy beliefs without becoming too narrow or specific” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 792). The 30-item instrument consists of “seven subscales: efficacy to influence decision making, efficacy to influence school decisions, instructional efficacy, disciplinary efficacy, efficacy to enlist parental involvement, efficacy to enlist community environment, and efficacy to create a positive school climate” (Tschannen-Moran & Woolfolk Hoy, 2001, p. 792). Participants responded to each item on a 9-point scale. Findings suggested that high self-efficacy leads to high positive effects. The complexity of teacher self-efficacy has made it difficult to measure.

Ashton vignettes. In this study, teachers were asked to respond to their effectiveness in solving a given situation in two phases. The first phase asked teachers to state on a scale from “extremely ineffective” to “extremely effective” how they would

respond to a certain situation (Ashton et al., 1984, p. 34). The second phase asked teachers to make a comparison to other teachers, from “much less effective than most teachers” to “much more effective than most teachers” (Ashton et al., 1984, p. 35). The study revealed that experienced teachers possess more confidence when planning and evaluating lessons, while preservice and less experienced teachers possess more confidence and higher efficacy with vignettes pertaining to student motivation.

Tschannen-Moran and Woolfolk Hoy Teachers’ Sense of Efficacy Scale (TSES). Based on the theoretical framework of Tschannen-Moran et al. (1998), Tschannen-Moran and Woolfolk Hoy (2001) developed the TSES also known as the Ohio State University scale. Tschannen-Moran et al.’s (1998) study suggested that the four sources of efficacy (mastery experience, vicarious experience, verbal persuasion, and physiological arousal) impact teacher goals and perseverance to complete a task and subsequently affect teaching behaviors (Bandura, 1977). The TSES measured 225 in-service and 111 preservice teachers’ sense of efficacy as it relates to eight student engagement tasks, eight classroom management tasks, and eight instructional practice tasks. Teachers responded to the efficacy tasks on a

9-point continuum with anchors at 1—Nothing, 3—Very Little, 5—Some Influence, 7—Quite A Bit, and 9—A Great Deal ... considering the combination of your current ability, resources, and opportunity to do each of the following in your present position. (Tschannen-Moran & Woolfolk Hoy, 2001, p. 948)

Research suggested that preservice teachers often lack the experience and pedagogical knowledge needed to sufficiently answer the subscale questions. Therefore, TSES summative scores should be used to determine preservice teacher levels of efficacy

(Tschannen-Moran & Woolfolk Hoy, 2001).

Tschannen-Moran and Woolfolk Hoy's (2006) study of 255 novice and career teachers used the TSES (Tschannen-Moran & Woolfolk Hoy, 2001) to measure and investigate two of Bandura's (1997) sources of efficacy: "verbal persuasion, with regard to interpersonal support from colleagues, parents, the community, and school administration and mastery experiences, defined by a sense of fulfillment with one's past teaching successes" (Tschannen-Moran & Woolfolk Hoy, 2006, pp. 944-945). The study findings suggested that teacher resources and social support were predicting self-efficacy factors for novice teachers; therefore, it is extremely important to support beginning teachers (Tschannen-Moran & Woolfolk Hoy, 2006). Supporting beginning teachers helps develop their sense of efficacy (Woolfolk Hoy & Hoy, 2003). In the words of Woolfolk in an interview on her research of self-efficacy,

We will never have the perfect curriculum or teaching strategy, but teachers who set high goals, who persist, who try another strategy when one approach is found wanting—in other words, teachers who have a high sense of efficacy and act on it—are more likely to have students who learn. (Shaughnessy, 2004, pp. 156-157)

Mathematics teaching self-efficacy scale. Teacher self-efficacy research has prompted the development of content-specific measures. Although there have been many studies on teacher self-efficacy, there is limited research on mathematics teaching efficacy (Klassen, Tze, Betts, & Gordon, 2011; Shaughnessy, 2004).

Enochs et al. (2000) developed the first MTEBI specific to mathematics teacher self-efficacy. Three hundred twenty-four preservice elementary teacher education students responded to the 21-item scale on two independent factors: 13 items on the

PMTE and eight items on the MTOE (Enochs et al., 2000). “The PMTE subscale addresses the preservice teachers’ beliefs in their individual capabilities to be effective mathematics teachers. The MTOE subscale addresses the preservice teachers’ beliefs that effective teaching of mathematics can bring about student learning regardless of external factors” (Swars, 2007, p. 5). The MTEBI uses a Likert scale with five categories: strongly agree, agree, uncertain, disagree, and strongly disagree. Using the MTEBI, Moseley, Utley, and Bryant (2006) found that teacher sense of PMTE and MTOE increased significantly when taking an integrated mathematics and science course, while students participating in a non-integrated course demonstrated no change.

Turner, Cruz, and Papakonstantinou (2004) developed their own mathematics teaching self-efficacy scale based on Quiñones (1995) self-efficacy survey. In their study, 101 teachers participated in a summer program based on the NCTM practices. The participants were administered the teaching self-efficacy scale and completed questionnaires prior to the start of the program and at the end of the program regarding demographics and questions related to their beliefs on learning and teaching mathematics. Teachers were allowed to observe others, practice their new teaching practices within the class, share feedback with other participants, and provide effective feedback. These activities are all sources to increase self-efficacy (Bandura 1997). Their findings revealed professional development that focused on the NCTM practices, one of the core features of CCSSM (NCTM, 2010b), increases mathematics teaching self-efficacy. Overall, teachers who completed the summer program left with a much higher sense of self-efficacy (Turner et al., 2004). Using a variety of models to meet the needs of all learners (working individually, in pairs, and in groups) is also much more likely to be

upheld by a teacher with high self-efficacy (Turner et al., 2004, p. 3).

Rethlefsen and Park's (2011) study was similar to Turner et al.'s (2004) research. Their study evaluated preservice teachers' mathematics teaching self-efficacy after the participants completed an NCTM practices mathematics course. Based on the BAR model, the teachers' mathematics self-efficacy increased on the MTEBI scale. According to England (2010), the BAR model method when used as Singapore Mathematics intended provides an opportunity for students to use rectangular bars to represent and solve word problems relating unknown and known numerical quantities.

Similar to the MTEBI scale, the MBI is a 48-item Likert scale instrument that consists of three subscales: 16 curriculum items: belief that mathematics should be taught so that students will problem solve; 15 learner items: the belief that students can develop their own mathematical knowledge; and 17 teachers items: the belief that mathematics instruction should be delivered so students create their own mathematical knowledge (Peterson, Fennema, Carpenter, & Loef, 1989, as modified by the Cognitively Guided Instruction Project). Responses range from strongly agree to strongly disagree. The higher the score, the more the results are cognitively aligned.

Research suggests that teachers, specifically elementary mathematics teachers, have low mathematics teaching efficacy and those levels improve after mathematical training (Klassen & Chiu, 2010). Successful reform in mathematics education begins with recruiting highly qualified elementary teachers with high levels of mathematics teaching efficacy (National Council on Teacher Quality, 2008). Although there is limited mathematics teaching efficacy research, evidence suggests that low teaching self-efficacy as well as low self-efficacy results in low mathematics achievement of elementary

students (Ashton & Webb, 1986; Bandura, 1997).

This study aims to highlight mathematics teaching efficacy of elementary teachers and the impact professional development has on mathematics teaching efficacy. The next section examines the role professional development has on developing mathematics teaching self-efficacy, beginning with effective mathematics professional development, followed by what effective mathematics instruction looks like.

Effective Teacher Professional Development

On June 2, 2010, North Carolina adopted the CCSS. Standards were not fully implemented into the classroom until the 2012-2013 school year. Forty-two states have fully implemented CCSSM for the basis of mathematics instruction (CCSSI, 2017). The goal of Common Core instruction is to prepare students so they will graduate career and college ready. “Who is in charge of the reality that must change to achieve the Common Core State Standards for Mathematics (CCSSM)? Teachers are” (Melton, Marrongelle, Smith, & Sztajn, 2012, p. 3). This can be difficult when teachers have low mathematical self-efficacy and low mathematical teaching efficacy. “To meet these new standards, teachers will have to learn new teaching practices. This is not just about providing professional development but about providing effective professional development” (Gulamhussein, 2013, p. 2).

NSDC (2009) defined professional development as “a comprehensive, sustained, and intensive approach to improving teachers’ and principals’ effectiveness in raising student achievement” (p. 1). NSDC further defined the components of professional development as the following:

Professional development fosters collective responsibility for improved student

performance and must be comprised of professional learning that: (1) is aligned with rigorous state student academic achievement standards as well as related local educational agency and school improvement goals; (2) is conducted among educators at the school and facilitated by well-prepared school principals and/or school-based professional development coaches, mentors, master teachers, or other teacher leaders; and (3) primarily occurs several times per week among established teams of teachers, principals, and other instructional staff members where the teams of educators engage in a continuous cycle of improvement. (p. 1)

Killion and Roy (2009) defined professional development as “a comprehensive, sustained, and intensive approach to improving teachers' and principals' effectiveness in raising student achievement” (p. 18). Research has proven that high-quality professional development develops the most effective and efficacious teachers (Guskey, 2003). The most successful professional development occurs when learning “is job-embedded, occurring in the workplace rather than in workshops; engages people in the work rather than listening to presentations about the work; and is collective rather than individual” (DuFour & Fullan, 2013, p. 54).

Guskey (2002) stated that high-quality professional development is a central component of nearly every modern proposal for improving education. “Professional development programs are systematic efforts to bring about change in the classroom practices of teachers, in their attitudes and beliefs, and in the learning outcomes of students” (p. 381).

Research shows that teacher instructional practices change only after they actually

notice student achievement (Guskey, 2002). Gulamhussein's (2013) research outlines five principles for effective professional development:

Sessions have a significant duration and the process is ongoing; There is support for a teacher during the implementation stage that addresses the specific challenges of changing classroom practice; Sessions and activities are active, not passive; The professional development process uses modeling, a strategy found to be highly effective in helping teachers understand a new practice; and The content is discipline- or grade level specific, rather than generic. (pp. 3-4)

In a 2-year study, Jacob and McGovern (2015) investigated teacher development in three large school districts and one mid-size charter school. The districts employ more than 20,000 teachers and serve approximately 400,000 students with 69% being low socioeconomic status. In order to examine whether professional development is effective, the study investigated three major issues: Do teachers become better after participating in professional learning opportunities; do teachers believe that professional development really works; and is the money spent on professional development really worth it? Findings from the study suggested that 70% of the teacher evaluation rating remains either the same or declines as a result of district professional development programs. Of the teachers who showed improvement, there was no correlation between teacher performance and participation in training. Although nearly half of the participants agreed that professional development has a lasting effect on their instructional practices, fewer than 40% indicated that professional development "is a good use of my time" (Jacob & McGovern, 2015, p. 2). The districts spent an estimated \$18,000 per teacher per year on professional development, which equates to

approximately 19 school days or approximately 10% of the school year. Some research suggests that money spent on professional development is not worth it. “Some may argue that we should drop our investment in teacher development in response to these findings. We disagree” (Jacob & McGovern, 2015, p. 3). Instead of decreasing or omitting professional development, Jacob and McGovern’s (2015) study recommended revising professional development so that it is continuous, focused, and reformed to efficiently meet the needs of teachers, build their self-efficacy, and increase student achievement. “To do this, we recommend that school systems: REDEFINE what it means to help teachers improve, REEVALUATE existing professional learning supports and programs, and REINVENT how we support effective teaching at scale” (Jacob & McGovern, 2015, p. 3).

Studies suggest that professional development influences teacher sense of efficacy. Tschannen-Moran and McMaster (2009) investigated the impact four professional development formats have on teacher self-efficacy and implementation of refined teaching practices. Mastery experience, the major source of efficacy according to Bandura (1997), was implemented in their study. Although findings from the study revealed that all program formats improve teacher efficacy, no particular professional development program inspired teachers to use learned teaching practices with their curriculum (Tschannen-Moran & McMaster, 2009).

Mathematics Teacher Professional Development

NCTM (2010b) stated that the “goal of mathematics professional development is to improve instruction in order to improve student learning” (p. 1). Mathematics professional development should increase elementary teacher self-efficacy by building

teacher mathematical knowledge and their efficacy to use their knowledge in the classroom; building teacher capacity to identify, analyze, and improve student mathematical thinking and reason; and building teacher practices as well as building external stakeholder relationships to support continuous learning. Mathematics professional development should be focused on higher order mathematics content and pedagogy. Many mathematics curricula follow the NCTM (2010a) guide. Curriculum affords teachers to be facilitators where they actively engage with students instead of instructing from a textbook. Teachers are expected to provide focus and rigor as well as help students build conceptual understanding (Achieve the Core, 2012).

Mathematics professional development is only effective if the content learned can be implemented immediately into classroom instruction (Firestone et al., 2005; Kilpatrick et al., 2001). “The teacher is not only a communicator but a model. Somebody who does not see anything beautiful or powerful about mathematics is not likely to ignite others with a sense of the intrinsic excitement of the subject” (Bruner, 1960, p. 54). According to NCTM (2000, 2006), mathematics professional development should provide mathematics teachers knowledge to actively engage students in a meaningful experience that will, in turn, build student mathematical thinking and reasoning. Turner et al. (2004) stated, “Professional development programs are widely recognized as being successful in their ability to augment teachers’ feeling of confidence for teaching mathematics” (p. 1).

Guskey’s (1986) framework suggests that effective mathematical professional development leads to change in teacher classroom practices and leads to change in student learning outcomes, which consequently results in a change in teacher beliefs and self-efficacy as indicated in Figure 11.

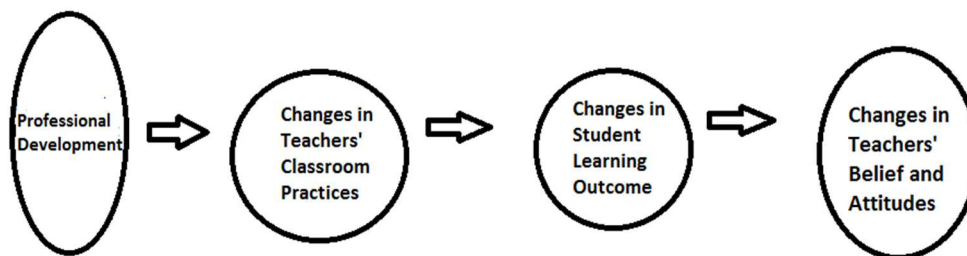


Figure 11. Guskey's Model of the Process of Teacher Change.

Effective professional development leads to the process of teacher change, which subsequently enhances teacher learning and ultimately improves student achievement.

Garet, Porter, Desimone, Birman, and Yoon's (2001) study was the first large empirical study that examined the impact professional development has on teacher knowledge and learning. One thousand ninety-seven mathematics and science teachers across the nation used the Teacher Activity Survey from the Eisenhower Professional Development Program to conduct a study of the impact professional development has on mathematics and science teacher learning and instructional practices. The Eisenhower Professional Development Program was developed as a component of Title II of the Elementary and Secondary Education Act (ESEA). The program focused on using professional development to develop teacher learning and instructional practice (U.S. Department of Education, 1999). According to Garet et al.'s (2001) study, there are three core features of effective professional development that improve teacher learning and change their instructional practice: "a focus on content knowledge, opportunities for active learning, and coherence with other learning activities" (p. 916). Features that affect teacher learning were the type of the professional development activity, collective participation, and the length of time the session lasted. Their study revealed that

sustained professional development that focuses on specific content and allows for collective professional learning has the greatest impact on mathematics and science teachers' mathematics efficacy, instructional practices, and ultimately student achievement.

Similar to Tschannen-Moran and McMaster's (2009) research, Ross and Bruce (2007) conducted a professional development program designed to increase 106 sixth grade mathematics teachers' levels of efficacy. Teachers attended a full day session and then three 2-hour sessions specific to Bandura's (1997) four sources of efficacy. Control and treatment groups completed the TSES before and after the program. Facilitators modeled standards-based teaching practices. The participants applied what they learned in their own classroom and discussed their experience during the next session. Three measures of teacher efficacy were investigated: student engagement, instructional practices, and efficacy for classroom management. The treatment group scored higher than the control group on all three measures. A teacher with a high sense of teacher self-efficacy has more control over their classroom and is more likely to have a classroom that is student centered (Hoy, 2000).

North Carolina State University's (2011) report examined the effects of CCSSM professional development. The report suggests the following nine components of professional development for high-quality implementation of the CCSSM content and practices:

1. PD provides opportunities for teachers to engage with the CCSSM content and the CCSSM practices in a focused and integrated way.
2. PD materials are needed that explicitly address the content and practices

of the CCSSM and provide vivid images of teaching and learning that are consistent with CCSSM.

3. PD takes into account existing knowledge about effective ways to organize learning experiences for teachers of mathematics.
4. Programs of PD provide a continuous and coherent set of experiences in which practicing mathematics teachers engage over an extended period of time.
5. PD uses expert facilitation to ensure teacher learning of CCSSM at scale.
6. Strong programs of PD target a variety of role groups with the education system and attend to the professional needs of each group as the system builds capacity at all levels.
7. Members of the general public need to be apprised on how the CCSSM will impact instruction and learning in our nation's classrooms.
8. PD programs are regularly assessed to provide formative information for program improvement and revision and to establish the effectiveness of the programs.
9. PD consortia are needed to oversee and improve the role PD plays in successful implementation of the CCSSM. (p. 9)

Chapter Summary

The review of literature in this chapter focuses on the impact CCSSM professional development has on elementary teacher self-efficacy. CCSSM, teacher self-efficacy, mathematics teaching efficacy, measures of teacher self-efficacy, and effective mathematics professional development provide a framework within their contexts and

present an overview of past and current research. In a response to change mathematics teachers' pedagogy, build conceptual understanding, and ultimately increase student achievement scores, the CCSSM was adopted (CCSSI, 2017). Research reveals that changes in curriculum demands a change in teacher beliefs in themselves and their students' ability to learn (Achieve the Core, 2012).

The studies on the implementation of effective mathematical professional development for CCSSM build teacher self-efficacy (Guskey, 1986). When mathematics self-efficacy increases, mathematics anxiety decreases (Swars et al., 2006), attitudes in mathematics become positive, and student learning is enhanced (Ashton & Webb, 1986). The effectiveness of teachers is the ultimate component of student achievement. Teachers who are familiar with the curriculum possess less anxiety and are more apt to effectively implement CCSSM into their daily instruction (Reece, 2014). Limited studies are available on CCSSM professional development implementation and the effects it has on elementary mathematics teaching efficacy and student learning; however, there is evidence of low mathematics achievement of United States elementary students. There are numerous studies that indicate teacher efficacy is one of the major contributing factors to student achievement, instructional practices, and beliefs in student abilities to learn (Ashton & Webb, 1986; Bandura, 1977). This study provided additional literature related to elementary mathematics teaching efficacy and CCSSM professional development effects on self-efficacy.

Chapter 3: Methodology

Introduction

The purpose of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured North Carolina EOG assessments was investigated. The following section outlines the research questions, participants, research design, instrumentation, procedures, data collection, data analysis, delimitation, limitations, and a summary. The research questions that guided the investigation were

1. What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers' mathematics teaching efficacy?
2. What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment?

Participants

The school system chosen for this study is located in southeastern North Carolina. Approximately 4,084 of 9,600 students are elementary. The district in which the study took place has a population consisting of 57.2% economically disadvantaged, 13.2% exceptional children, 9.5% academically gifted, 65.8% Caucasian, 14.3% African-American, 14.8% Hispanic, and 5.1% other (multi-racial, Asian, Native American).

Research Design

This study followed a mixed-method protocol. Qualitative and quantitative

methods were used to answer the research questions. Grades 3-5 teachers who participated in a math cohort entitled “Building a Community of Mathematicians” were chosen as the group for this study. The cohort consisted of 26 K-2 level teachers and 33 Grades 3-5 teachers. Through the completion of four modules as described in Figure 12, participants received 20 hours of face-to-face as well as online professional development that focused on the core features of CCSSM.

Module 1: Participants will gain an understanding of the eight mathematical practices in order to build a strong math community in their classroom. Strategies will be given for promoting mathematical discourse in the classroom to support active engagement and student understanding.

Module 2: “Digging Deeper with Problem Solving, Formative Assessment, and Math Interventions” Participants will dig deeper into problem solving and develop an understanding of how formative assessment is used to create targeted math groups.

Module 3: “Beefing up the Core- Writing in Math and Mini Lessons” Participants will examine how to make the most out of their math mini lessons and gain strategies for using writing as a tool for learning math.

Module 4: “Bringing it all together” Participants will learn how to refine and infuse math centers/stations with rigor by using formative assessment and accountability.

Figure 12. Four Modules Studied in the Math Cohort.

In Module 1, teachers explored ways to structure classroom routines in order to maximize the learning of all students. Student-centered problem-solving strategies were introduced. Module 2 provided participants with a deeper focus on problem-solving strategies through the exploration of the Singapore method for problem-solving as well as other grade-specific strategies. Current data were reviewed and intervention strategies were discussed. Module 3 provided participants with opportunities to implement writing into their mathematics instruction. Misconceptions that surfaced through the sessions were discussed in Module 4 along with the sharing of successes and additional questions

answered through the Google Classroom platform.

Quantitative data were collected by measuring the participants' levels of teacher self-efficacy using the MTEBI (Enochs et al., 2000) and through the results of EOG mathematics student test scores. The first research question analyzed the results of the MTEBI. Correlations were used to examine the results of Enoch's et al.'s (2000) MTEBI and North Carolina EOG data in math from responding teachers to analyze the second research question. To develop a broader perspective about elementary teachers' mathematics teaching efficacy, a qualitative analysis of interview data was implemented. The interview process questioned participants who demonstrated both high or low self-efficacy in mathematics on the MTEBI survey.

Instrumentation

Mathematics teaching self-efficacy was measured using Enoch's et al.'s (2000) MTEBI. A copy of the MTEBI is included in Appendix A. Enoch's et al. found two significant subscales while testing reliability for the MTEBI: (a) the PMTE subscale and (b) the MTOE. Identified in Figure 13, the scale consisted of 13 personal expectancy mathematics teaching efficacies and eight mathematics teaching outcome expectancies.

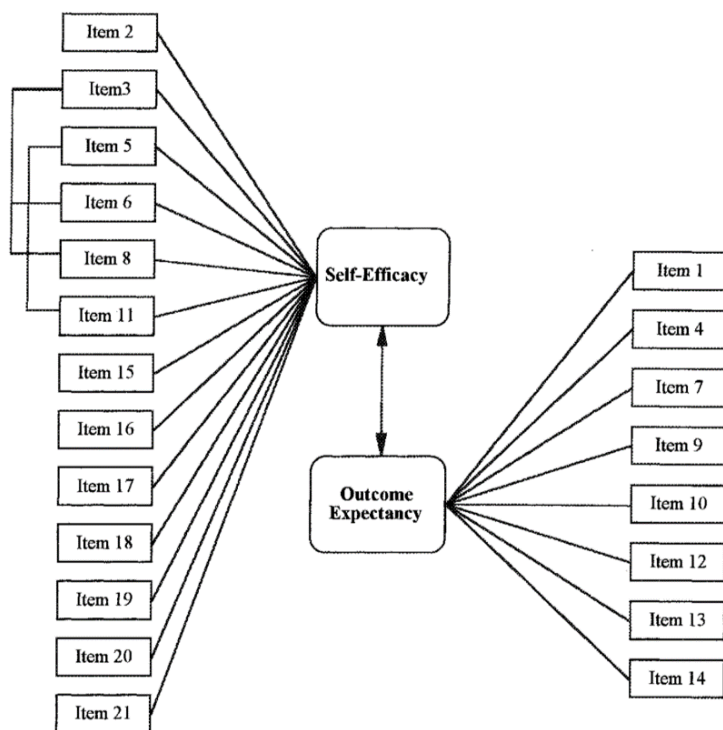


Figure 13. Factor Structure of MTEB Scale Items.

MTEBI. The MTEBI is accepted to be a valid and reliable measure of self-efficacy (Klassen et al., 2011). The survey instrument also contains a demographic section to collect descriptive data. The MTEBI established factorial validity through a study with 324 participants from three colleges and universities in California, South Carolina, and Michigan. Modified from the Science Teaching Efficacy Beliefs Instrument (Riggs & Enochs, 1990), the MTEBI is

subjected to rigorous confirmatory factor analysis. Reliability analysis produced an alpha coefficient of 0.88 for the PMTE scale and an alpha coefficient of 0.75 for the MTOE scale (n=324). Confirmatory factor analysis indicates that the two scales (PMTE and MTOE) are independent, adding to the construct validity of the MTEBI. (Enochs et al., 2000, p. 194)

Additionally, the validity and reliability of the MTEBI have also been supported by various studies, including both preservice and in-service teachers (Alkhateeb, 2004; Barta & Ostrogorsky, 2004).

Participants in this study completed the MTEBI two times during their participation in the cohort: beginning and end. The MTEBI also included a demographic section. The demographic section in the survey was used to examine the characteristics and qualifications of the participants included in the study. An analysis of the results was used to determine if there was a difference in mathematics teaching efficacy beliefs upon completion of the cohort. The cohort consisted of 26 K-2 level teachers and 33 Grades 3-5 teachers. Thirty-one percent of the Grades 3-5 teachers participated in the interview session.

EOG mathematics assessment. The EOG mathematics assessment is administered yearly to Grades 3-8 students to assess mastery of the North Carolina Standard Course of Study (NCSCS). Aligned to the NCSCS, the assessments have between 44 to 50 operational items. All of the test items in Grades 3 and 4 are multiple choice. Only 38 of the Grade 5 items are multiple choice, with six gridded-in response items (NCDPI, 2017). The Grades 3, 4, and 5 mathematics assessments have 10 field test items embedded as well as a calculator active and a calculator inactive section. The range of total items on the assessment outlined in Figure 14 is based on the standard course of study.

Domain	Grade 3	Grade 4	Grade 5
Operations and Algebraic Thinking	30–35%	12–17%	5–10%
Number and Operations in Base Ten	5–10%	22–27%	22–27%
Number and Operations—Fractions	20–25%	27–32%	47–52%
Measurement and Data	22–27%	12–17%	10–15%
Geometry	10–15%	12–17%	2–7%
Total	100%	100%	100%

Figure 14. Weight Distribution of Grades 3-5.

Weight distributions are also aligned to the major works of the grades outlined in Figure 15. Student performance on the EOG mathematics assessment is based on five achievement levels as described in Figure 15.

Grade	Level 1	Level 2	Level 3	Level 4	Level 5
3	≤ 439	440-447	448-450	451-459	≥ 460
4	≤ 440	441-448	449-450	451-459	≥ 460
5	≤ 440	441-448	449-450	451-459	≥ 460

Figure 15. Math Grades 3-8 Achievement Level Ranges (Cut Scores).

In October 2013, the North Carolina State Board of Education (NCSBE) adopted college- and career-readiness achievement standards for the EOG. “The new Achievement Level 3 identifies students who are prepared for the next grade but do not meet the college-and-career readiness standard” (NCDPI, 2017, p. 1). The EOG mathematics assessment is a reliable and valid assessment.

Three broad categories of reliability coefficients are recognized as appropriate indices for establishing reliability in tests: (a) coefficients derived from the administration of parallel forms in independent testing sessions (alternate-form coefficients); (b) coefficients obtained by administration of the same instrument on separate occasions (test retest coefficients); and (c) coefficients based on the

relationships among scores derived from individual items or subsets of the items within a test, all data accruing from a single administration of the test (internal consistency coefficients). (NCDPI, 2014, p. 1)

The internal-consistency coefficient, determined by coefficient alpha (α), estimates how items on the EOG are related. Outlined in Figure 16 is the reliability coefficients for Grades 3-5 EOG mathematics items.

Grade	Form		
	A	B	C
3	0.91	0.92	0.91
4	0.92	0.92	0.92
5	0.91	0.92	0.91

Figure 16. Grades 3-5 EOG Mathematics Reliabilities.

“The North Carolina Statewide Testing Program meets or exceeds industry norms for reliability” (p. 1). The reliabilities range is greater than or equal to 0.91 for all mathematics Grades 3-5 forms of the test.

According to the NCDPI (2015) Technical Report, validation of the mathematics EOG for alignment to the standards and instruction was completed using the Surveys of the Enacted Curriculum model. The Wisconsin Center for Education Research conducted a study of the alignment of the assessments to the content standards, and experienced teachers across the state were recruited to write items for the assessments. “The use of individuals with these types of experiences helped to ensure that the items were valid measures of mathematics” (NCDPI, 2015, p. 9). Interview questions were validated through content validation.

Interview questions. Content validation was established through the review of the questions by three elementary mathematics education specialists: an elementary

director of student learning and two elementary instructional coaches with over 10 years of teaching experience each.

Procedure

As part of the doctoral program requirements, the researcher requested and received approval from Gardner Webb's Institutional Review Board (IRB) by submitting an IRB Proposal Request Application (see Appendix C). Permission to conduct the study and collect the data was provided by the district's superintendent.

Prior to beginning the research, approval of all persons participating in the study was obtained and all the confidentiality requirements were met. Enochs et al. (2000) granted permission to use their MTEBI on October 8, 2017 via email (see Appendix D). The MTEBI was distributed to teachers in the fall of 2017 by the elementary director (see Appendix E) before the start of the cohort and at the end of the cohort. Based on the results of the survey, questions for the teacher interview were created.

Data Collection

The goal of the MTEBI was to measure the participants' level of mathematics teaching efficacy before and after participating in professional development relating to CCSSM through a cohort format. Using Google Form, the MTEBI was regenerated. The purpose of the interview is to provide additional information concerning participant teaching beliefs and the impact professional development has on mathematics teaching efficacy beliefs of elementary mathematics teachers. Interview questions outlined in Appendix F were created to support the results of the MTEBI. The elementary director sent the link to the survey via email (see Appendix E) for the participants to complete prior to the start and at the completion of the cohort. In order to achieve at least a 60%

return rate, several email reminders were sent to participants.

Teacher interviews were conducted to further investigate teacher self-efficacy in teaching mathematics. Based on the results from the MTEBI, individuals who completed both the pre and postsurvey and revealed significant changes in their self-efficacy were invited to participate in the interview section of the study. Utilizing these criteria, five teachers were invited to participate further in this research. The interview process lasted approximately 20 minutes. Individual interviews were recorded, transcribed, kept confidential, and used only as part of this study. The recordings were destroyed once the transcriptions were completed for accuracy.

Third- through fifth-grade student achievement data were collected from the North Carolina EOG scale scores in mathematics. Test data were collected from the district accountability of testing director for the current year. A mean score for each Grades 3-5 mathematics teacher was used to correlate student achievement scores to teacher self-efficacy for teaching mathematics as measured by the MTEBI. The results were compiled and reported in spreadsheet form. The spreadsheet was converted and entered into Statistical Package for the Social Sciences (SPSS), a statistical software tool for analysis.

Data Analysis

Data analysis began by coding the data and transferring it into SPSS. To examine Research Question 1, “What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers’ mathematics teaching efficacy,” a paired sample t test was used to compare the means of teacher efficacy before and after the professional development from the MTEBI.

According to Harris (1997), a paired sample t test is used when the same participants are measured twice with a pre and postdesign.

To examine Research Question 2, “What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment,” the degree of association between the students’ mathematics EOG test scores was correlated with their teachers’ mathematics teaching efficacy scores as measures by the MTEBI. The independent variable was the teachers’ mathematics teaching self-efficacy, and the dependent variable was the students’ EOG mathematics test scores. For this study, a Pearson correlation coefficient was used. A Pearson correlation coefficient is used when “only one independent variable is being studied” (Creswell, 2014, p. 356). Significance was established at the .05 level of probability. The interview transcribed notes were analyzed for patterns. These qualitative findings were compared and contrasted with the findings from the quantitative data.

Delimitations

The researcher chose to limit this study to elementary teachers. This study was further delimited to one school district’s elementary teachers who participated in a math cohort in the fall of 2017. Although, the study could be extended to other elementary teachers across the region, the researcher chose to limit the research to one school district. This limits the impact of facilitator and topics discussed during the session. The participants in this cohort were instructed by the same facilitators, and the main goal was the implementation of the core features of CCSSM (focus, coherence, and rigor) and the eight mathematical practices.

Limitations

For this study, there are limitations that need to be taken into consideration when reviewing the results of the study: (a) relationship to participants and (b) mandatory versus voluntary participation.

Relationship to participants. The researcher chose elementary teachers in the school district where the researcher serves on the district's instructional team as director of secondary student learning. Although, the researcher assured participants that their feedback was confidential and used for the sole purpose of research, it is difficult to encourage complete honesty. According to Creswell (2014), participants should be provided with informed consent before participating in the interview to assure openness and intimacy of the interview session as it may lead respondents to disclose formative information.

Mandatory versus voluntary participation. While some participated because it was mandatory by school and district staff, others participated on a voluntary basis; therefore, the number of teachers who completed the TSES survey and were willing to be interviewed is a limiting factor.

Chapter Summary

In summary, this study examined the influence of mathematics professional development for CCSSM and the effects it has on elementary mathematics teaching self-efficacy and student achievement. This chapter provided the methodology of this research. Research questions, research design, participants, data collection, and description of the instruments were provided. Findings from the data analyses are presented in Chapter 4. Chapter 5 consists of study findings and conclusions.

Chapter 4: Presentation of the Data

The purpose of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured North Carolina EOG assessments was investigated. This chapter presents the findings from this research to address the following research questions.

1. What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers' mathematics teaching efficacy?
2. What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment?

This chapter begins with a descriptive analysis of the sample including the results from the MTEBI. Finally, the results of the statistical analysis performed to examine the research questions are presented.

Participants

During the research, participants completed the MTEBI (Enochs et al., 2000). The instrument was administered to participants prior to the start of a semester-long mathematics cohort and readministered at the completion of the cohort for quantitative comparison with the pretest. Table 1 displays a demographic description of the participants in this study.

Table 1

Participants Demographic Information

		Current Grade Level						
		K	First	Second	Third	Fourth	Fifth	Total
Gender	Female	4	9	14	9	12	11	59
	Male							
	Total	4	9	14	9	12	11	59
Yrs of Experience	0-4 years	1	2	1	4	1		9
	5-9 years			1		1	1	3
	10-14 years		4	1	2	2	1	10
	15-19 years			3	1	2	2	8
	20-24 years	2	1	3		2	5	13
	25-29 years	1	2	5	2	4	2	16
	>=30 years							
	Total	4	9	14	9	12	11	59
Race	White	3	9	14	9	11	10	56
	Black	1					1	2
	Hispanic					1		1
	Other							
	Total	4	9	14	9	12	11	59
Age	< 25	1	3	1	3	1	2	11
	25-29		1	5	3	4	2	15
	30-34		3	3	2	3	1	12
	35-39	2	2	3	1	1	3	12
	40-44			1		3	2	6
	>=45	1		1			1	3
	Total	4	9	14	9	12	11	59

Fifty-nine female teachers participated in this study. With regard to race/ethnicity, 56 (94.9%) were White, two (3.3%) were Hispanic, and one (1.7%) was Black. Nearly half of the participants (29; 49.2%) had between 20-29 years of experience, nine (15.3%) had 0-4 years, three (5%) had 5-9 years, 10 (16.9%) had 10-14 years, and eight (13.6 %) of the teachers surveyed had 15-19 years of experiences. Eleven (18.6%) of the participants were less than 25 of age, 15 (25.4%) were between the ages of 25-29, 12 (20.3%) were between the ages of 30-34, 12 (20.3%) were between the ages of 35-39, six (10.2%) were between the ages of 40-44, and three (5.1%) were over the age of 45. In the fall of 2017, the breakdown of current grade taught was as follows: four (6.8%) kindergarten, nine (15.3%) first, 14 (23.7%) second, nine (15.3%) third, 12 (20.3%) fourth, and 11 (18.6%) fifth.

Descriptive Analysis of Data

A descriptive analysis was conducted on data collected from the 59 participants in this study. In order to answer the research questions, responses were converted to numerical data, and the data were analyzed using SPSS. Reverse scoring of negatively worded items was implemented to allow for consistency item values.

Mathematics Teaching Efficacy Belief Instrument

Assigned a value from 1-5, the 21 items on the MTEBI contain five categories: strongly agree, agree, uncertain, disagree, and strongly disagree. Strongly disagree is represented with 1, while 5 represents strongly agree. The range of scores possible on the MTEBI is 21-105, with a score of 21 indicating low mathematics teaching efficacy and a score of 105 indicating high mathematics teaching efficacy. Eight of the 21 items are on the MTOE subscale, while the other 13 are on the PMTE subscale.

According to Enochs and Huinker (1995), the PMTE subscale score ranges from 13 to 65 and the MTOE subscale score ranges from 10 to 50. “The PMTE subscale addresses the teachers’ beliefs in their individual capabilities to be effective mathematics teachers. The MTOE subscale addresses the preservice teachers’ beliefs that effective teaching of mathematics can bring about student learning regardless of external factors” (Swars, 2007, p. 5).

Analysis of Research Question 1

To examine Research Question 1, several statistical t tests were used to analyze the dispersion of the teachers’ PTME and MTOE responses. The tests also determined if there were significant differences between mean scores. Fourteen of the 59 participants completed the presurvey only, 19 completed the postsurvey only, and 26 completed both the pre and postsurvey. The researcher used the PMTE and the MTOE subscales to examine teaching efficacy beliefs based on grade level and years of experience. Paired samples t tests were used to analyze the mean score differences from pretest to posttest and to compare mean score differences within the group of participants who completed both surveys. A two-tailed test was also used to test the mean scores from pretest to posttest of participants who completed both surveys.

Teacher efficacy results by grade level. The first characteristic tested was teacher current grade level taught and whether there was any significant difference in teacher PMTE and MTOE when examining grade level. Mean scores and standard deviations for the pre- and post-PMTE by grade level are displayed in Table 2 for the 59 participants. Pre- and post-MTOE by grade level are displayed in Table 3.

Table 2

Total Pre- and Post-PMTE by Grade

		Pre-PMTE			Post-PMTE		
		N	Mean	SD	N	Mean	SD
Current Grade Level	K	4	51.50	.71	4	40.00	9.38
	First	9	44.88	7.43	9	36.80	2.17
	Second	14	47.00	6.61	14	40.11	4.26
	Third	9	49.17	7.00	9	38.43	2.64
	Fourth	12	49.25	7.29	12	39.33	5.41
	Fifth	11	47.86	3.39	11	38.73	3.00

For every grade level, the participant's PMTE as well as the standard deviations decreased for the PMTE subscale.

Table 3

Total Pre- and Post-MTOE by Grade

		Pre-MOTE			Post-MOTE		
		N	Mean	SD	N	Mean	SD
Current Grade Level	K	4	27.50	4.95	4	29.25	2.87
	First	9	29.50	3.16	9	30.60	5.46
	Second	14	29.44	3.61	14	26.11	3.72
	Third	9	30.17	3.31	9	29.57	2.44
	Fourth	12	28.88	4.09	12	30.00	4.24
	Fifth	11	25.71	3.90	11	28.55	2.98

All of the participants except for second- and third-grade teachers displayed an overall slight gain in their MTOE. Second- and third-grade teacher MTOE results show a decrease in the mean score from the pretest ($M=29.44$, $SD=3.61$, $M=30.17$, $SD=3.31$) to the posttest ($M=26.11$, $SD=3.72$, $M=29.57$, $SD=2.44$, respectively).

Teacher efficacy results by teacher experience. Displayed in Table 4 is the pre-

and post-PMTE results by years of experience. There were only three teachers who completed the survey with 5-9 years of experience. Two of the three teachers completed the presurvey only, while one completed the postsurvey only. Consequently, there is no standard deviation displayed for 5-9 years of experience.

Table 4

Pre- and Post-PMTE by Years of Experience

Yrs of Experience	Pre-PMTE			Post-PMTE		
	N	Mean	SD	N	Mean	SD
0-4 years	9	48.50	5.13	9	39.17	2.93
5-9 years	3	51.00	7.07	3	36.00	.
10-14 years	10	47.43	6.80	10	37.43	1.90
15-19 years	8	46.50	4.59	8	41.33	4.18
20-24 years	13	47.89	5.97	13	37.82	2.99
25-29 years	16	47.13	9.34	16	39.79	6.28
>=30 years	

The mean scores and the standard deviation for the PMTE decreased for all participants regardless of years of experience. Table 5 presents the pre- and post-MTOE.

Table 5

Pre- and Post-MTOE by Years of Experience

Yrs of Experience	Pre-MTOE			Post-MTOE		
	N	Mean	SD	N	Mean	SD
0-4 years	9	29.00	2.93	9	28.17	2.48
5-9 years	3	31.00	1.41	3	32.00	.
10-14 years	10	27.14	2.54	10	29.71	3.20
15-19 years	8	28.83	4.02	8	29.67	2.73
20-24 years	13	28.33	5.00	13	28.09	2.81
25-29 years	16	29.50	4.38	16	28.57	5.45
>=30 years	

The MTOE subscale mean scores decreased for teachers with less than 4 years and over 20 years of experience. Teachers with years of experience between 10-19 years mean MTOE increased from the pre and postsurvey.

Teacher efficacy by participants that complete both surveys. Twenty-six of the 59 participants completed both the pre and postsurvey. Displayed in Table 6, a paired sample *t* test was used to determine whether there was a difference in the participants' overall PMTE and MTOE.

Table 6

Paired Sample t Test of Participants Who Completed Both Surveys

		Mean	N	SD	St. Error Mean
Pair 1	Post-PMTE	39.3077	26	4.22156	.82792
	Pre-PMTE	47.1923	26	6.81187	1.33592
Pair 2	Post-MTOE	29.1923	26	4.10871	.80579
	Pre-MTOE	28.6923	26	4.25929	.83532

For the PMTE subscale, the pretest mean score (Mean=47.1923) was higher than the posttest (Mean=39.3077). Unlike the PMTE, there were no significant differences between the pretest and the posttest on the MTOE subscale. The mean score for teacher beliefs in their individual impact on student outcomes showed a slight increase from the pretest (Mean=28.6923) to the posttest (Mean=29.1923). According to the MTOE standard deviations, the scores are also similarly dispersed for the pre and posttest (SD=4.25929 and SD=4.10871, respectively).

Outlined in Table 7 is a paired samples *t* test that was conducted to compare the difference in pre- and post-PMTE and MTOE scores.

Table 7

Paired Samples t Test—Paired Differences of Pre- and Post-PMTE and MTOE

		Mean	SD	SD Mean Error	95% Confidence Interval of the difference		t	df	Sig 2-tailed
					Lower	Upper			
Pair 1	Post-PMTE-Pre-PMTE	-7.88462	9.42052	1.84752	-11.68964	-4.07959	-4.268	25	.000
Pair 2	Post-MTOE-Pre-MTOE	.50000	5.16333	1.01261	-1.58552	2.58552	.494	25	.626

The mean difference for the PMTE was -7.88462 with a 95% confidence interval for the difference in the means ranging from -11.68964 to -4.07959. This paired *t* test showed a significant negative difference ($t(26)=-4.268, p < .05$) between the pre-PMTE and post-PMTE scores indicating that there was a significant negative difference in mathematics teaching efficacy beliefs upon completion of the Building a Community of Mathematicians cohort. The mean difference for the MTOE was .50000 with a 95% confidence interval for the difference in the means ranging from -1.58552 to 2.58552. A paired *t* test showed no significant difference ($t(26)=-.494, p > .05$), indicating that the results were likely to occur by chance.

Analysis of Research Question 2

Student achievement data. The mean class scale score for each third through fifth grade mathematics teacher who participated in this study was used to determine correlations with their students' academic achievement on the North Carolina EOG mathematics assessment. The mean class scale scores for 253 students were used to

correlate with teacher self-efficacy for teaching mathematics as measured by the MTEBI. In third grade, mathematics scores range from 439-460 and above; 440-460 and above for fourth and fifth grade (Table 8).

Table 8

EOG Mathematics Performance Level Description

Math Performance Level	Descriptors	Grade 3 Scale Score	Grade 4 Scale Score	Grade 5 Scale Score
I	Level 1- Limited knowledge and skills	≤ 439	≤ 440	≤ 440
II	Level 2-Partial knowledge and skills	440-447	441-448	441-448
III	Level 3- Sufficient knowledge and skills	448-450	449-451	449-451
IV	Level 4 Solid knowledge and skills	451-459	451-459	451-459
V	Level 5 Superior knowledge and skills	≥ 460	≥ 460	≥ 460

The participants in this study consisted of 26 K-2 level teachers and 33 Grades 3-5 teachers. Of the 33 Grades 3-5 teachers, only 21 taught mathematics. Tables 9-11 display the mean score for the 21 participants who were third through fifth grade mathematics teachers for the 2017-2018 school year.

Table 9

Fifth Grade Student Average EOG Scale Mean Scores

Identifier	Grade	Mean Student Scale Score
PP	5	449.8
SS	5	449
NN	5	448.7
GG	5	454.9
TT	5	452.2
R	5	449.9
U	5	459.7
JJ	5	459

Fifth grade scores ranged from 448.7 to 459.7.

Table 10

Fourth Grade Student Average EOG Scale Mean Scores

Identifier	Grade	Mean Student Scale Score
MM	4	452.1
Z	4	443.2
KK	4	447.4
V	4	452.2
O	4	445.4
LL	4	457.1
CC	4	452.9
MM	4	454.4

Table 11

Third Grade Student Average EOG Scale Mean Scores

Identifier	Grade	Mean Student Scale Score
G	3	446.2
E	3	444.5
HH	3	456.8
A	3	447.4
D	3	446.7

Third grade student achievement scores ranged from 444.5 to 456.8. The average math scores for all grades ranged from 443.2 to 459. Twenty-four percent of the participants taught third grade, while 38% taught fourth grade, and 38% taught fifth grade.

A correlation matrix was performed to examine Research Question 2: “What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment?” This test described the degree of association between the students’ mean mathematics EOG test scores with their teachers’ post-PMTE and MTOE subscale scores as measures by the MTEBI. Sixteen of the 21 third through fifth grade mathematics teachers completed the pre- and post-MTEBI. Based on the correlation in Table 12, there is not a significant relationship between student EOG mathematics achievement scores and the teachers’ post-MTOE ($r=-.067, p>.05$) or the post-PMTE ($r=-.078, p>.05$) scores.

Table 12

Correlation of Student Test Scores to Post-PMTE and MTOE

		EOG Math Mean Score	Post-PMTE	Post-MTOE
EOG Math Mean Score	Pearson Correlation	1	-.078	-.067
	Sig. (2-tailed)		.774	.806
Post-PMTE	N	16	16	16
	Pearson Correlation	-.078	1	.324
	Sig. (2-tailed)	.774		.106
Post-MTOE	N	16	26	26
	Pearson Correlation	-.067	.324	1
	Sig. (2-tailed)	.806	.106	
	N	16	26	26

Interview data. As indicated above, 16 of the 21 third through fifth grade mathematics teachers completed the pre- and post-MTEBI. To develop a broader perspective about elementary teachers' mathematics teaching efficacy, five of the 16 teachers (31.3%) agreed to participate in the qualitative process of this study. The purpose of the interview is to provide additional information concerning the participants' mathematics teaching belief and the impact professional development has on mathematics teaching efficacy beliefs of elementary mathematics teachers. Interview questions outlined in Appendix F were created to support the results of the MTEBI. Findings from the interviews revealed these three themes: (a) teachers use a variety of instructional practices in the classroom; (b) professional development provides an opportunity for continuous collaboration; and (c) teacher beliefs in their abilities to help students succeed.

Theme 1: Instructional practices. One theme that emerged from the research

was instructional practices. Through the analysis of the data, the participants used a variety of instructional strategies in their classrooms. The instructional practices most described by the participants were the use of hands-on manipulatives and small group instruction. The use of hands-on manipulatives in their classroom was described by all the participants. Teacher U and Teacher FF stated using hands-on manipulatives when students do not understand a concept when taught the first time. Teacher U stated, “if my students don’t understand it the first time, I will definitely go back over it. Diverse manipulatives and reteaching several different methods using the manipulatives help students solve problems.” Teacher FF echoed this sentiment:

We then solve problems using hands-on manipulatives activities. We are right there working on the manipulatives together. Students then work on a rotation of manipulatives, then they have to go back and do a rotation on their own using those skills learned.

Teacher D described using Base 10 blocks to teach place value:

Place value is one of the main concepts in elementary that students should know in order to be successful at the next grade level and in high school. When students have trouble with place value, I get the base 10 blocks and a place value chart. I start off with small numbers, like 13, students model this with 1 flat and 3 ones. I then move on to numbers like 78, 7 flats and 8 ones. Once, they master two digit numbers, I then add the hundreds place and move to three-digit numbers.

Teacher Z stated, “the use of manipulatives is an effected way to help low-performing students understand word problems.” Teacher LL, a third-grade teacher with

only 1 year of experience stated,

The use of manipulatives helps students visualize the problem. For instance, if students are having difficulties with skills like comparing and computing with fractions, the use of manipulatives like cuisenaire rods helps them visualize which fractions are larger. They can then draw their own models from the models they build with the cuisenaire rods, and this helps them solve the problem.

Teacher LL also expressed her concerns about the “overuse of manipulatives” in a state-tested subject:

I feel that manipulatives are a great strategy to teach any student math but I feel that they are overused. We have to find a balance and a way to move from using the manipulative to solving the problem because students cannot use them on their end-of-grade test.

Participants also described using small group instruction as an instructional practice to help students succeed. The participants described using small groups as the means to influence their students’ achievement in mathematics despite their background, for low-performing students, and for students who do not learn a math concept the first time. Teacher LL specifically articulated why she uses small group instruction in her classroom:

When students do not understand the lesson taught in whole group, I then go to small groups and based on their understanding students are grouped accordingly. I have an enrichment group for the ones who know it, so they can receive an extension, and small groups are grouped according to how much of the knowledge is missing. Then once the students master the skill in a small group,

they have to demonstrate their knowledge independently. Small group instruction allows you to individualize instruction for all students.

Additionally, small group instruction was expressed by Teacher Z:

If a student doesn't get it the first time, I then put them in groups, like guided math small groups. After looking at multiple sources of data, I determine the groups and what are the areas that need improvement. After documentation and working with the groups, I work with individual students.

Teacher D described how she introduces small group instruction into her classroom:

I make my own problems when it comes to the practice problem sets. I teach a quick whole group lesson, I teach a small group lesson, then they do an independent practice. Then through spiral review, I use a performance task from DPI which is a strong instructional tool I also used with small groups of students based on their gaps.

Teacher U described how she incorporated small group instruction into her classroom: "I teach a quick whole group lesson then they do an independent practice with that." She continued describing a strategy entitled "Next Steps":

When a student is struggling, I do something called the Next Steps. Every student uses a check-list and so if they have a particular skill they need to work on, their Next Step will not be enrichment but their Next Steps will be on skills that they need to master. So, I organize small groups based on students Next Steps.

Teacher U detailed an additional strategy called "Stick it Together" that was shared on a resource document by one of the cohort participants:

Stick it Together is one that I started using immediately after the cohort ended. I modified it just a little. I took Number Talks and put it all together. Students come in and they have a Problem of the Day from Engage, which is already spiraled. I take that and they do that independently on a sticky note. They have to explain what they did. Every student has to explain how they did it, how to go about that problem, and how they got the answer.

Theme 2: Professional development provides an opportunity for continuous collaboration. Another theme that emerged from this study was that professional development provided an opportunity for continuous collaboration. Participants were asked about the impact of the professional development received through the cohort and the influence on their confidence in their skills and abilities to teach mathematics effectively. Two of the participants (Teachers Z and LL) eluded that the participation in the cohort helped to verify what they already knew. Teacher Z shared, “It was an affirmation and confirmed what I already knew. However, I was enlightened to more sources because that cohort allowed for more conversation for teachers to share more strategies.” Teacher LL described how participation in the cohort boosted her confidence and made her more cognizant when communicating with her students:

The thing that I like was the article we started with. It was the what not to do and what not to say in relation to math. I have a couple that I added to that list. I notice how it makes me rethink how I teach especially multiplication. If you are working with decimals, you can't say multiplication makes your answer higher. I think it helped with vertical alignment, with everyone's thinking and vocabulary. Teacher FF added, “It was definitely worthwhile and beneficial. It just reinforced

my confidence.” Teacher U responded, “I definitely put many more tools in my toolbox. Everything was electronic as well. If you saw something in it, you were able to go find it later.” Teacher D referred back to her answer of the MTEBI survey regarding Question 19: When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better. Teacher D stated,

It was a question on the survey about how to help students understand math better and are you usually at a loss coming up with ways to help them. When I answered that question the first time, I answered disagreed. The cohort provided me with a toolbox of strategies to help my students.”

I then asked the teacher how she replied to the question on the post-MTEBI. Her response was, “strongly agree.”

Additional responses relating to collaboration were “I now have a cohort of teachers that I collaborate with on a daily basis”; “I wish that this cohort would meet regularly throughout the year”; “It was nice to know that you were not alone in regards to certain issue”; “Not only did I learn so many strategies to support student learning, I learned so much just from talking with the other teachers.”

Theme 3: Teacher self-efficacy beliefs. The third theme that emerged was teacher perceptions and beliefs in their ability to impact student achievement despite external factors. During the interview, participants were asked if they contributed to the success of struggling students when they perform well. Participant responses ranged from “yes” to “definitely.” When asked to explain their responses, the teachers elaborated on how they contributed. Teacher FF explained,

Yes, personally, I strive to make math more fun, I show them different ways of

doing things. I am showing them a new strategy and an easier way to do the math. I struggled with math personally and if I can break it down for them then that helps them understand.

Teachers U and LL referred to their ability to impact student achievement through multiple ways of instruction. Teacher U stated, “definitely, I think if you show students multiple ways to solve a math problem they can definitely solve it. I personally think that they see it differently because of the way I taught them.” Similarly, Teacher LL expressed, “I think I contribute to their growth because I use diverse methods of instruction so that everyone can learn.” Teachers D and Z referred to the use of data to impact their students’ achievement. “After looking at multiple sources of data, I determine what are the areas that need improvement, then after documentation and working with that child, I can see that they made growth,” reported Teacher D.

Teacher Z noted,

When a child struggles, interventions on some level have to take place. If you really assess their work, you can determine what the weaknesses are. Once I determine individual gaps, I can then determine the best method to help my students.

Three themes the researcher identified from the findings were (a) instructional practices, (b) professional development, and (b) teacher self-efficacy beliefs. Evident in the analysis of the interviews, the participants used various instructional practices to enhance student learning and agreed that professional development provided an opportunity for continuous collaboration; teaching efficacy increased as a result of their participation in professional development.

Chapter Summary

The purpose of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured by North Carolina EOG assessments was investigated. To respond to Research Question 1, "What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers' mathematics teaching efficacy," a paired sample t test was used to compare the means of teacher efficacy before and after the professional development from the MTEBI.

To respond to examine Research Question 2, "What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment," a correlation matrix was performed to describe the degree of association among the students' mathematics EOG test scores with their teachers' mathematics teaching efficacy scores as measured by the MTEBI. The independent variable was the teachers' mathematics teaching self-efficacy, and the dependent variable was the students' EOG mathematics test scores. For this study, a Pearson correlation coefficient was used. Significance was established at the .05 level of probability. The interview transcribed notes were analyzed for patterns and themes. These themes provided additional information concerning the participants' mathematics teaching belief and the impact professional development has on mathematics teaching efficacy beliefs of elementary mathematics teachers. Findings of this study, conclusions, implications, and recommendations for further research are presented in Chapter 5.

Chapter 5: Findings

The purpose of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured by North Carolina EOG assessments was investigated. This chapter summarizes the findings of this study, provides conclusions, explains implications, and makes recommendations for further research.

Findings Related to Research Question 1

What is the impact of a professional development program focusing on the core features of common core mathematics on elementary teachers' mathematics teaching efficacy? The first research question examined the impact on elementary mathematics teaching efficacy after participation in a semester-long cohort. The teachers' mathematics teaching efficacy was measured using the MTEBI in regard to two subscales: PMTE beliefs and MTOE beliefs. The PMTE and MTOE mean scores were compared from pretest to posttest. Unlike many studies investigated, the PTME decreased from pretest to posttest in this study. Utley, Moseley, and Bryant (2005) found that PMTE increased throughout mathematics methods courses. Swars (2007) also showed that participants' mathematics teaching efficacy increased during their methods coursework for preservice teachers. Mosely et al. (2006) conducted a later study that resulted in teachers' PMTE increasing throughout participation in a mathematics methods course if there was an integrated mathematics course, while students participating in a non-integrated course demonstrated no change.

The data from this study revealed a decline in the teachers' PMTE from pre to

post. The overall PMTE for years of experience and grade level currently teaching decreased after teachers participated in the cohort. The PMTE for the 26 participants who completed both the pre and postsurvey demonstrated a significantly negative effect ($p=.000, p < .05$) from pre to postsurvey scores. The PMTE mean between the pre and post was -7.88462 indicating a decrease in total scores from the first survey. The total mean PMTE score from the presurvey was 47.1923; the total mean score from the postsurvey was 39.3077. The change in PMTE scores for participants who completed both surveys demonstrated a significant decrease between pre and postsurvey scores. Similar to the results from this study, Jacob and McGovern's (2015) study reviewed that 80% of the teachers whose observation scores had declined substantially over the past several years indicated that their instructional practices had improved "some" or "tremendously."

According to Swars (2007), the PMTE subscale addresses teacher beliefs in their individual capabilities to be effective mathematics teachers, while the MTOE subscale addresses teacher beliefs that effective teaching of mathematics can result in student achievement regardless of external factors. Although the overall MTOE increased slightly from pre to posttest for participants who completed both surveys in this study, there was no significant difference in regard to their MTOE beliefs. Similar to Isiksal-Bostan (2016), what stood out in regard to years of experience was a decreased in MTOE for teachers with 0-4 years and 20-29 years of experience. It should be noted that teachers with 0-4 or 20-29 years of experience represent 65.2% of second- and third-grade teachers. For teachers with 0-4 years of experience, the mean pretest score was $M=29.50$, and the post was $M=28.57$. For teachers with 20-24 years of experience, the

mean pretest score was $M=28.33$, and the post was $M=28.09$. For teachers with 25-29 years of experience, the mean pretest score was $M=29.50$, and the post was $M=28.57$. A possible explanation for the decrease in these groups of participant MTOE scores is based on Bandura's (1997) study, which details the four main sources of self-efficacy: enactive mastery, vicarious modeling, verbal persuasion, and physiological and emotional arousal. Teachers with 0-4 years of experience lack enactive mastery experiences. Enactive mastery is the most important source of increasing self-efficacy (Bandura, 1997). Through repeated experiences, teachers develop a sense of fulfillment with one's past teaching success; and as a result, their belief to influence others' success would increase. However, teachers with 20-29 years of experience who would have many repeated mastery experiences also decreased for the group pre-MTOE ($M=29.00$) to the post-MTOE ($M=28.17$). Although studies have yielded some success for teachers after participation in professional development, it is often difficult to change the efficacy of experienced teachers since a teacher's sense of efficacy is deep rooted over time. Bandura (1997) stressed that self-efficacy beliefs are most important in early learning and that once developed, they are resistant to change.

The overall MTOE mean between the pre and post was .5000, indicating a slight increase in total scores from the first survey. The total mean MTOE score from the overall presurvey was 28.6923; the total score from the postsurvey was 29.1923. The change in MTOE scores for participants who completed both surveys was not significantly different ($p=.626$, $p<.05$) enough to indicate a relationship between pre and postsurvey.

Findings Related to Research Question 2

What is the correlation between elementary mathematics teaching self-efficacy scores and student achievement as measured from the EOG mathematics assessment? The findings from the correlation outlined in Table 12 demonstrated that there was no statistically significant relationship between teacher efficacies post-MTOE ($r=-.067, p > 0.05$) or post-PMTE ($r=-.078, p > 0.05$) and students' mean mathematics EOG assessment scores. The Pearson correlation coefficient for the relationship between post-PMTE and achievement scores is $r=-.078$. The value of $r=-.078$ indicates a slight negative relationship between post-PMTE and student achievement scores. The results of the analysis indicated the correlation between post-PMTE and student achievement scores is not significant, $r=-.078, n=16, p=0.774$. The Pearson correlation coefficient of $r=-.078$ is likely to occur by chance and not because of a linear relationship that exists between post-PMTE and achievement scores.

The correlation coefficient for the relationship between post-MTOE and achievement scores is $r=-.067$. The value of $r=-.067$ indicates a slight negative relationship between post-MTOE and student achievement scores. The results of the analysis indicated the correlation between post-MTOE and student achievement scores is not significant, $r=-.067, n=16, p=0.806$. The Pearson correlation coefficient of $r=-.067$ is likely to occur by chance and not because of a linear relationship that exists between post-MTOE and student achievement scores.

Based on the literature review throughout this study, it was clear that professional development and training has a positive impact on mathematics teaching efficacy, which ultimately leads to student growth and achievement. Smith (2010) stated that focusing on

building teachers self-efficacy can boost teacher confidence and ultimately increase student achievement. Guskey's (1982) studies revealed positive correlations between student successes and failures and teacher self-efficacy. His study also revealed that highly efficacious teachers demonstrated positive attitudes when implementing new instructional practices to improve learning for students. Jacob and McGovern's (2015) study recommended revising professional development so that it is continuous, focused, and reformed to efficiently meet the needs of teachers, build their self-efficacy, and increase student achievement. In this study, teacher efficacy was not significant to student achievement. It should be noted that the teachers' post-PMTE and MTOE scores were correlated to student proficiency scores. Student scores may have increased, but the improvements are not demonstrated by the mean scale scores since there was not a comparison of previous scores included in the dataset. Regardless of the teachers' efficacy scores in this study, all participants indicated in their interviews that they could positively influence their students' achievement in mathematics despite their students' background and other external factors.

Findings of Interview Data

The purpose of the interviews was to provide additional information concerning the participants' mathematics teaching belief and the impact professional development had on teaching efficacy beliefs of elementary teachers. Presented in this section are the results from the interviews and the themes contained in the responses. Themes were identified by coded data that existed in the five interviews.

Theme 1: Instructional practices. Due to the implementation of CCSS, teachers have to expand their instructional practices to prepare students for career and college

readiness (Achieve the Core, 2012). The teachers in this study referred to the use of Hands-on Manipulatives, Small-Group Instruction, Number Talks, Stick it Together, Zearn, and Illustrated Mathematics to build conceptual understanding for their students. The use of hands-on manipulatives and small group instruction were the most common instructional practices mentioned by the teachers. Teacher D mentioned the use of manipulatives to help her students understand the concept of place value. Teacher LL described how the use of manipulatives helped her students understand fractions. Although the use of hands-on manipulatives was extremely important to Teacher LL, she emphasized concerns with the “overuse” of manipulatives. Four of the five participants described using small group instruction as an instructional practice to help students succeed. Gibson and Dembo’s (1984) study suggested that teachers with high efficacy were more likely to implement small group instruction opposed to the whole group and were more likely to guide and help students persist to the correct answer. Teacher Z described how small group instruction reduces the “student to teacher ratio which allows the teacher to focus on the skills needed for students to move forward.” It was evident the participants used small group instruction as the means to provide more individualized instruction for their students. Teachers D and LL expressed that small group instruction is used daily in their classrooms to individualize instruction for all students. They talked about small group instruction not only for remedial students but for students who need enrichment as well. A critical component missing from the participants’ instructional practices discussions was the assessment component. The participants were asked, “when students do not understand a concept taught for the first time, do you think you are able to use a variety of other instructional strategies or assessments to help them learn?”

The teachers did not mention any type of student assessment as it relates their instructional practices. When teachers successfully engage in learning about CCSSM, they understand what curriculum should be taught as well as how to teach and assess it to achieve student achievement and success (Achieve the Core, 2012; Great Minds, 2016).

Theme 2: Professional development provides an opportunity for continuous collaboration. Dufour and Fullan (2013) stated the most successful professional development occurs when learning engages people in active work rather than listening to presentations and is collective rather than individual. All participants responded positively to their participation in the cohort and the influence on their confidence in their skills and abilities to teach mathematics effectively. Teacher F explained how she adapted strategies learned in the cohort to meet the needs of her students. Teacher FF stated that participation in the cohort confirmed that what she was already doing in her classroom was the most effective method to achieve success with her students.

The participants also stated that their classroom instruction practices changed as a result of their participation in the cohort. Respondents from Kane et al.'s (2016) study were asked about professional development they have received, resources used, observation on their instruction, and many other features of their Common Core implementation. Eighty-two percent of the respondents "reported that they have changed more than half of their instructional materials in response to the Common Core" (Kane et al., 2016, p. 4). Teacher LL stated that she is mindful of what she says in relation to math: "If you are working with decimals, you can't say multiplication makes your answer higher." Teacher Z, a veteran with over 20 years of experience, stated that she has a new level of confidence and ability to try new strategies and activities. Changes in

instructional practices are crucial in the implementation of the Common Core Curriculum. According to NCTM (2013), the CCSS offered a foundation for the development of more rigorous, focused, coherent curricula, instruction, and assessments that promote conceptual understanding. Teacher U stated,

Students can only develop conceptual understanding when we focus on the skills being taught without the use of rote memorization. I learned a strategy named CPA. You have to move from the concrete to the pictorial stage, then to solve the abstract problem. Through my participation in the cohort, I learned that CPA is the most efficient method to help underperforming students.

Garet et al.'s (2001) study revealed that sustained professional development that focuses on specific content and allows for collective professional learning has the greatest impact on mathematics and science teachers' mathematics efficacy.

Theme 3: Teacher self-efficacy beliefs. Participants stated that they could successfully help students achieve success regardless of external factors. Three of the interview questions asked participants about their ability to successfully help students achieve success regardless of varying backgrounds. The consensus of the teachers revealed that they were very confident in their ability to help their students achieve success. Teacher D contributed to her students by making math fun. Regardless of years of experience or grade level taught, the teachers commented that they believed in their ability to teach mathematics effectively. Findings supported by the interviews in this study suggested that teachers strongly agreed that they positively contributed to their students' improvement and academic success regardless of their backgrounds.

Implications of the Study

A number of implications have resulted from this study. The implications are important as they highlight approaches to predicting teaching efficacy and new developments for the implementation of effective mathematics teaching professional development for elementary math teachers. For administrators, the research implied that grades taught should not be taken into consideration when predicting teacher efficacy. In order to increase the mathematics teaching self-efficacy of elementary teachers, the researcher recommended that administrators should focus on teachers who are switching grades rather than certain grade levels. Teachers who are familiar with the curriculum possess less anxiety and are more apt to effectively implement the standards in their daily instruction (Reece, 2014).

Years of experience should be taken into consideration when predicting teacher efficacy. There is evidence in this study to suggest that years of experience should be taken into consideration when predicting mathematics teaching efficacy of elementary teachers. For administrators, the findings from this study demonstrated higher PMTE and MTOE efficacy among preservice teachers. Isiksal-Bostan (2016) conducted a longitudinal study to investigate how teachers' self-efficacy changed as they progressed from preservice to in-service teachers. Findings from his study revealed that preservice teachers' mathematics teaching efficacy beliefs increase during their education preparation programs but decrease during the first years of teaching. The researcher recommended that administrators have to seek methods to properly support and retain effective teachers. It is extremely important to support beginning teachers (Tschannen-Moran & Woolfolk Hoy, 2006). Supporting beginning teachers helps develop their sense

of efficacy (Woolfolk Hoy & Hoy, 2003).

In addition, administrators have a responsibility to promote job-embedded opportunities for their staff. The implementation of the Common Core Curriculum will ultimately become the burden of the district and school leaders but, more specifically, the principal. Although this study did not investigate the correlation between principal leadership and mathematics teaching efficacy, findings from the literature implied that administrator leadership is a key factor on teacher efficacy (NSDC, 2009). Many principals believe they do not possess the skills to be the math instructional leader in their building. Principals have an obligation to positively impact mathematics teaching self-efficacy for their teachers. The researcher suggested that principals seek and facilitate job-embedded professional development opportunities for their teachers that actively engages the participants in collaborative hands-on activities. During the interview process of this study, all participants stressed the benefits of participation in the cohort and knowledge gained through collaboration with their colleagues.

For school districts, this research suggested that professional development is an important component of elementary mathematics teaching efficacy. The goal of increasing elementary mathematics teaching efficacy is to provide meaningful and effective professional development that actively engages the participants. According to Garet et al.'s (2001) study, there are three core features of effective professional development that improve teacher learning and change their instructional practice: "a focus on content knowledge, opportunities for active learning, and coherence with other learning activities" (p. 916). Additionally, this study provided district leaders with information on professional development based on teacher perception. Professional

development based on teacher perception empowers teachers, builds self-efficacy, and supports the district's learning-teaching agenda (Tschannen-Moran & Woolfolk Hoy, 2001). The effectiveness of teachers is the ultimate component of student achievement. Teachers who are familiar with the curriculum possess less anxiety and are more apt to effectively implement the standards in their daily instruction (Reece, 2014).

Professional development programs should also focus on building instructional practices. Although many programs focus on developing and building conceptual knowledge, they tend to overlook teachers who already possess mathematics knowledge but may have difficulties with delivery of instruction. Simply understanding math does not assure successful teaching. In Module 2 of the cohort, the participants investigated problem-solving strategies and how to use formative assessments to create targeted math groups. It should be noted that the participants failed to address student assessments during instructional practices responses.

Additionally, the results from this study implied that professional development should be focused on increasing mathematics teaching efficacy. Teachers need to be able to develop self-efficacy from their participation in professional development activities. A high sense of efficacy influences teachers' expectations, attributions, and ultimately student achievement (Bandura, 1997). Similar to Hoy and Woolfolk's (1993) study, the researcher found that the MTOE of teachers tends to increase when they learn more about a particular concept. Teachers who participated in this cohort consistently reported high levels of outcome teaching efficacy during the interviews. Likely, contributing sources of their efficacy outcome beliefs may be based on mastery experiences. Future research may provide further insight by comparing the teachers' self-efficacy beliefs with

classroom observations of the actual implementation of strategies used in the cohort.

The last implication is that professional development should be continuous. Follow-up after professional development opportunities is critical for the continuous growth of teachers. Participants in this study referred to the electronic toolbox of strategies, which allowed them to share instructional practices as well as revisit strategies that enhanced learning for their students. Currently, the school district provides time and space for this cohort of teachers to meet, collaborate, and share ideas via Google Hangouts or face to face. During these quarterly sessions, teachers collaborate on instructional strategies that meet the needs of all students. Professional development programs similar to the cohort in this study provide a supportive environment that leads to continuous learning for teachers.

Recommendations for Future Research

Results from this study may be used to make well-informed decisions about mathematics professional development opportunities. Professional development has the potential to affect teacher efficacy, and teaching efficacy has the potential to influence student achievement. Guskey's (1986) framework suggested that effective mathematical professional development leads to change in teacher classroom practices, which leads to change in student learning outcomes, which consequently results in a change in teacher beliefs and self-efficacy as indicated in Figure 11.

Effective professional development leads to the process of teacher change, which subsequently enhances teacher learning and ultimately improves student achievement. The research in this study refuted the findings of Guskey's (1986) study as well as other research detailed in the literature review.

Unlike the quantitative data, the qualitative data indicated that the participants were highly efficacious in their beliefs that they could impact student outcomes. Based on the quantitative data, the PMTE declined significantly after the completion of the cohort. As stated in Chapter 3, the PMTE subscale addresses teacher beliefs in their capabilities to be effective mathematics teachers. A reason why the PMTE declined while the interview responses revealed strong positive efficacy, may lie in the response rate of the postsurvey. The postsurvey contained a lower response rate, especially among Grades 3-5 teachers. As a result, the researcher reopened the survey to allow for a valid representation of the group. Future studies should investigate the response rate for pre and postsurveys to ensure that the sample is a true representation of the group investigated. Conclusions drawn from unrepresentative data may result in erroneous outcomes. Additional, multiple reminders may need to be sent to the participants after the completion of any professional development program, and the importance of the study should be stressed. The postsurvey has equal value as the presurvey because it has the potential to provide the most useful immediate feedback to increase knowledge.

Another reason for the discrepancies may be the relationship between the participants and the interviewer. The researcher chose elementary teachers in the school district where the researcher serves on the district's instructional team as director of secondary student learning. Although the researcher assured participants that their feedback was confidential and used for the sole purpose of this study, it was difficult to gauge if participants were completely honest. This might suggest a need for the interviews to be administered by a proxy. A proxy would eliminate response bias and the impact on future findings in a negative manner.

The researcher also recommends repeating this study but with a larger sample size. Although the interviews provided additional information concerning the participants' teaching beliefs, additional research using additional data collection measures such as classroom observations and focus groups would help strengthen the findings. To validate the data in this study, the researcher also recommends repeating this study but using a control group. A control group would not receive professional development but would complete the MTEBI. This would help rule out chance, explanations of results, and help assess the effect of the intervention on the experiment group.

Over the years, mathematics has become a subject that causes anxiety and fear for many teachers, especially elementary teachers (Dorward & Hadley, 2011). Many of them had experienced difficulties in their own K-12 and college mathematics careers, which has led to difficulties in their mathematics instruction (NCTM, 2014). "It's not surprising that many elementary teachers struggle with the Common Core State Standards for Mathematics. Many early childhood teachers are actually frightened of math" (Raschka & Hemphil, 2015, p. 2). Numerous elementary mathematics teachers doubt their own ability and have chosen a profession where they think it will not matter (McAnallen, 2010). Future research investigating the relationship between prior experiences and their effects on elementary teaching mathematics efficacy would be beneficial to guide decisions on professional development.

Successful reform in mathematics education begins with recruiting highly qualified elementary teachers with high levels of mathematics teaching efficacy (National Council on Teacher Quality, 2008). Although this study did not correlate high levels of

mathematics teaching efficacy to higher achievement student scores, the researcher suggests that this study should be replicated. Instead of looking at an overall proficiency math score, prior student achievement should be considered to correlate growth of students to their teachers' mathematics teaching efficacy.

Conclusion

The goal of this mixed-method study was to examine whether professional development designed to include the core features of CCSSM has an effect on elementary mathematics teachers' self-efficacy. In addition, the influence of the teachers' sense of efficacy on their students' achievement as measured North Carolina EOG mathematics assessments was investigated.

To accomplish this goal, the researcher has examined the impact on Grades 3-5 teachers' mathematics teaching efficacy. These teachers participated in a math cohort entitled "Building a Community of Mathematicians." Through the completion of four modules as described in Figure 12, participants received 20 hours of face-to-face as well as online professional development that focused on the core features of CCSSM.

Quantitative data were collected by measuring participant levels of teacher self-efficacy using the MTEBI (Enochs et al., 2000) and through the results of EOG mathematics student test scores. Qualitative data were collected through teacher interviews. These interviews were conducted to further investigate teacher self-efficacy in teaching mathematics. Although the review of the literature revealed that teachers, specifically elementary mathematics teachers, have low mathematics teaching efficacy and those levels improve after mathematical training (Klassen & Chiu, 2010), the findings from this study refuted that claim. The findings from this study mirror the

findings from Jacob and McGovern's (2015) 2-year study. Their investigation examined the effects of professional development on teacher development. Similar to this study, findings suggested that 70% of the teachers' evaluation ratings remain either the same or decline as a result of the district's professional development programs. Of the teachers who showed improvement, there was no correlation between teacher performance and participation in training; however, listening to the teachers in this study led the researcher to believe that their participation in the mathematical cohort did, in fact, increase their teacher performance as well as enhance their mathematical teaching efficacy.

"It's not surprising that many elementary teachers struggle with the Common Core State Standards for Mathematics. Many early childhood teachers are actually frightened of math" (Raschka & Hemphil, 2015, p. 2). Numerous elementary mathematics teachers doubt their own ability and have chosen a profession where they think it will not matter (McAnallen, 2010). Distinct from the basic step-by-step algorithm, teachers are tasked with providing instruction that "builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems" (NCTM, 2014, p. 42).

Teacher self-efficacy is the most influential factor in developing teacher beliefs, student motivation, and achievement (Tschannen-Moran & Woolfolk Hoy, 2001). Evidence indicated that the implementation of the CCSSM has diminished teacher efficacy in mathematics instruction (Harris, 2010). The impact of CCSSM professional development will inform development and training programs and subsequently lead to successful implementation of the CCSS. Each school district has an obligation to equip

teachers with the toolbox needed to effectively implement CCSSM standards and ultimately prepare students for career and college readiness (CCSS, 2010). When teachers believe in their ability to do something well and persevere through the steps to get there, every child will attain success (Achieve the Core, 2012; Marzano & Toth, 2014; NCTM, 2010a).

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Appendix A
Mathematics Teaching Efficacy Beliefs Instrument

Directions: Please indicate your opinion about each of the statements below by circling the appropriate response at the right of each statement. Your answers are confidential.	KEY:				
	SA	A	U	D	SD
1. When a student does better than usual in mathematics it is often because the teacher exerted a little extra effort.	SA	A	U	D	SD
2. I will continually find better ways to teach mathematics.	SA	A	U	D	SD
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.	SA	A	U	D	SD
4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	SA	A	U	D	SD
5. I know how to teach mathematics concepts effectively.	SA	A	U	D	SD
6. I will not be very effective in monitoring mathematics activities.	SA	A	U	D	SD
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	SA	A	U	D	SD
8. I will generally teach mathematics ineffectively.	SA	A	U	D	SD
9. The inadequacy of a student's mathematics background can be overcome by good teaching.	SA	A	U	D	SD
10. When a low-achieving child progresses in mathematics, it is usually due to attention given by the teacher.	SA	A	U	D	SD
11. I understand mathematics concepts well enough to be effective in teaching mathematics.	SA	A	U	D	SD
12. The teacher is generally responsible for the achievement of students in mathematics.	SA	A	U	D	SD
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	SA	A	U	D	SD
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	SA	A	U	D	SD
15. I will find it difficult to use manipulatives to explain to students why mathematics works.	SA	A	U	D	SD
16. I will typically be able to answer students' questions.	SA	A	U	D	SD
17. I wonder if I will have the necessary skills to teach mathematics.	SA	A	U	D	SD
18. Given a choice, I will not invite the principal to evaluate my mathematics teaching.	SA	A	U	D	SD
19. When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	SA	A	U	D	SD
20. When teaching mathematics, I will usually welcome student questions.	SA	A	U	D	SD
21. I do not know what to do to turn students on to mathematics.	SA	A	U	D	SD

Taking from Enochs, L., Smith, P., and Huinker, D. Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics*, 2000,100 (4), 194-202.

Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) Scoring Instructions

- Step 1. Item Scoring: Items must be scored as follows: Strongly Agree = 5; Agree = 4; Uncertain = 3; Disagree = 2; and Strongly Disagree = 1.
- Step 2. The following items must be reversed scored in order to produce consistent values between positively and negatively worded items. Reversing these items will produce high scores for those high and low scores for those low in efficacy and outcome expectancy beliefs.

Item 3	Item 17
Item 6	Item 18
Item 8	Item 19
Item 15	Item 21

In SPSSx, this reverse scoring can be accomplished by using the recode command. For example, recode ITEM3 with the following command:

```
RECODE ITEM3 (5=1) (4=2) (2=4) (1=5)
```

- Step 3. Items for the two scales are scattered randomly throughout the MTEBI. The items designed to measure Personal Mathematics Teaching Efficacy Belief (SE) are as follows:

Item 2	Item 11	Item 18
Item 3	Item 15	Item 19
Item 5	Item 16	Item 20
Item 6	Item 17	Item 21
	Item 8	

Items designed to measure Outcome Expectancy (OE) are as follows:

Item 1	Item 9	Item 13
Item 4	Item 10	Item 14
Item 7	Item 12	



Note: In the computer program, DO NOT sum scale scores before the RECODE procedures have been completed. In SPSSx, this summation may be accomplished by the following COMPUTE command:

```
COMPUTE SESCALE = ITEM2 + ITEM3 + ITEM5 + ITEM6 + ITEM8 + ITEM11 + ITEM15 + ITEM16 + ITEM17 + ITEM18 + ITEM19 + ITEM20 + ITEM21
```

```
COMPUTE OESCALE = ITEM1 + ITEM4 + ITEM7 + ITEM9 + ITEM10 + ITEM12 + ITEM13 + ITEM14
```

Appendix B

Karin Hess Cognitive Rigor Matrix (2013)

<div>  HESS COGNITIVE RIGOR MATRIX (MATH-SCIENCE CRM): Applying Webb's Depth-of-Knowledge Levels to Bloom's Cognitive Process Dimensions </div> <div>  </div>				
Revised Bloom's Taxonomy	Webb's DOK Level 1 Recall & Reproduction	Webb's DOK Level 2 Skills & Concepts	Webb's DOK Level 3 Strategic Thinking/Reasoning	Webb's DOK Level 4 Extended Thinking
Remember Retrieve knowledge from long-term memory, recognize, recall, locate, identify	<ul style="list-style-type: none"> Recall, observe, & recognize facts, principles, properties Recall/ identify conversions among representations or numbers (e.g., customary and metric measures) 	Use these Hess CRM curricular examples with most mathematics or science assignments or assessments.		
Understand Construct meaning, clarify, paraphrase, represent, translate, illustrate, give examples, classify, categorize, summarize, generalize, infer a logical conclusion, predict, compare/contrast, match like ideas, explain, construct models	<ul style="list-style-type: none"> Evaluate an expression Locate points on a grid or number on number line Solve a one-step problem Represent math relationships in words, pictures, or symbols Read, write, compare decimals in scientific notation 	<ul style="list-style-type: none"> Specify and explain relationships (e.g., non-examples/examples; cause-effect) Make and record observations Explain steps followed Summarize results or concepts Make basic inferences or logical predictions from data/observations Use models /diagrams to represent or explain mathematical concepts Make and explain estimates 	<ul style="list-style-type: none"> Use concepts to solve non-routine problems Explain, generalize, or connect ideas using supporting evidence Make and justify conjectures Explain thinking/reasoning when more than one solution or approach is possible Explain phenomena in terms of concepts 	<ul style="list-style-type: none"> Relate mathematical or scientific concepts to other content areas, other domains, or other concepts Develop generalizations of the results obtained and the strategies used in investigation or readings) and apply to new problem situations
Apply Carry out or use a procedure in a given situation; carry out (apply to a familiar task), or use (apply) to an unfamiliar task	<ul style="list-style-type: none"> Follow simple procedures (recipe-type directions) Calculate, measure, apply a rule (e.g., rounding) Apply algorithm or formula (e.g., area, perimeter) Solve linear equations Make conversions among representations or numbers, or within and between customary and metric measures 	<ul style="list-style-type: none"> Select a procedure according to criteria and perform it Solve routine problem applying multiple concepts or decision points Retrieve information from a table, graph, or figure and use it solve a problem requiring multiple steps Translate between tables, graphs, words, and symbolic notations (e.g., graph data from a table) Construct models given criteria 	<ul style="list-style-type: none"> Design investigation for a specific purpose or research question Conduct a designed investigation Use concepts to solve non-routine problems Use & show reasoning, planning, and evidence Translate between problem & symbolic notation when not a direct translation 	<ul style="list-style-type: none"> Select or devise appropriate alternatives to solve a problem Conduct a project that identifies solution to a problem, and report on the process
Analyze Break into constituent parts, determine how parts relate, differentiate between relevant-irrelevant, distinguish, focus, select, organize, outline, find coherence, deconstruct	<ul style="list-style-type: none"> Retrieve information from a table or graph to answer a question Identify whether specific information is contained in graphic representations (e.g., table, graph, T-chart, diagram) Identify a pattern/trend 	<ul style="list-style-type: none"> Categorize, classify materials, data, figures based on characteristics Organize or order data Compare/ contrast figures or data Select appropriate graph and organize & display data Interpret data from a simple graph Extend a pattern 	<ul style="list-style-type: none"> Compare information within or across data sets or texts Analyze and draw conclusions from data, citing evidence Generalize a pattern Interpret data from complex graph Analyze similarities/differences between procedures or solutions 	<ul style="list-style-type: none"> Analyze multiple sources of information Analyze complex/extended mathematical relationships Gather, analyze, and synthesize information
Evaluate Make judgments based on criteria, check, detect inconsistencies or fallacies, judge, critique	"UG" – unsubstantiated generalizations = stating an opinion without providing any support for it!		<ul style="list-style-type: none"> Cite evidence and develop a logical argument for concepts or solutions Describe, compare, and contrast solution methods Verify reasonableness of results 	<ul style="list-style-type: none"> Gather, analyze, & evaluate information to draw conclusions Apply understanding in a novel way, provide argument or justification for the application
Create Reorganize elements into new patterns/structures, generate, hypothesize, design, plan, produce	<ul style="list-style-type: none"> Brainstorm ideas, concepts, or perspectives related to a topic 	<ul style="list-style-type: none"> Generate conjectures or hypotheses based on observations or prior knowledge and experience 	<ul style="list-style-type: none"> Synthesize information within one data set, source, or text Formulate an original problem given a situation Develop a scientific/mathematical model for a complex situation 	<ul style="list-style-type: none"> Synthesize information across multiple sources or texts Design a mathematical model to inform and solve a practical or abstract situation

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Hess, K. K. (2013). *Cognitive Rigor Matrix (Mathematics CRM): Applying Webb's depth-of-knowledge levels to Bloom's cognitive process dimensions*. Copyright 2013 by K. K. Hess.


Appendix C

Permission to Conduct the Study

Expedited IRB approval - Google Chrome
 https://outlook.office.com/owa/projection.aspx

Reply all | Delete Junk | ...

Expedited IRB approval

 Kathi Simpson
 Tue 7/31, 8:22 AM
 Lisa Lee; David Shellman; Seth Oprea


Inbox

Ms. Lee,
 Your IRB Application for the Expedited research project titled "The Impact of Common Core Mathematics Professional Development on Elementary Teaching Self-Efficacy and the Resulting Effects on their Student Achievement" has been approved, effective July 30, 2018. It has been assigned an expiration date of July 29, 2019, and an IRB file number of 18072603X.

Please be aware that if you need to continue your study beyond the Expiration Date, you must submit a Request for Continuance (<http://www.gardnerwebb.edu/Assets/gardnerwebb/academics/review-board/irb-request-research-continuance1.pdf>) prior to that date.

Best wishes for a productive investigation!
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Kathi Simpson
 Office Manager
 Secretary to the IRB
 Gayle Bolt Price School of Graduate Studies
 P (704) 406-3020 | F (704) 406-3859

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Appendix D

Permission from Dr. Huinker to use the Mathematics Teaching Efficacy Beliefs
Instrument

**DeAnn M Huinker** <huinker@uwm.edu>

8/22/17



to me ▾

Hi Alissa,

Yes, you have my permission to use the MTEBI for your research. I assume this is for your doctoral work. Upon completion of the research and writing I'd like to provide notification and an electronic copy of the final document.

Just for your information, unfortunately, Dr. Enochs passed away a couple years ago.

Best to you in your work,

DeAnn Huinker




 Dr. DeAnn Huinker, Mathematics Education
 Professor, Department of Curriculum and Instruction
 Director, Center for Mathematics and Science Education Research (CMSER)
 Board of Directors, National Council of Teachers of Mathematics (NCTM)
 Principal Investigator, *Pathways to Teacher Leadership in Mathematics*,
Strong Start Math Project, and *Transforming Fraction Teaching and Learning Projects*
 University of Wisconsin-Milwaukee
www.uwm.edu/cmser ~ huinker@uwm.edu




Appendix E


Invitation to Complete the MTEBI

Math Cohort 3 Teacher Efficacy Feedback Survey

Inbox x



 **B** [redacted] k12.nc.us> Jan 16  

to 

Cohort III Participants,

Thank you for your active participation in our recent math cohort.

Please fill out this Cohort 3 post/efficacy survey. We greatly appreciate your feedback and insights. If you have feedback to share outside of this survey, feel free to send me an email. I'm always happy to hear from you.

Please find the link to The Teacher Efficacy Google Form below:

<https://goo.gl/forms/Q398tq8dQQtyfY8C3>

Appendix F

Mathematics Teaching Efficacy Interview Questions

Directions to the Interviewees:

The following questions are designed to provide additional information about your teaching experience. You are encouraged to answer these questions as candidly and as completely as possible; the anonymity of your responses is assured. The interview normally takes approximately 20 minutes – although you may take as much time as you need to answer the questions. The results of this study will be available to you upon request.

1. When a student who struggles with mathematics performs better, do you think that you may have contributed to that growth? Please explain your response.
2. When students do not understand a concept taught for the first time, do you think you are able to use a variety of other instructional strategies or assessments to help them learn? Can you describe some of the strategies you may have used to contribute to this achievement?
3. How much do you think can you influence a low performing student to perform better in mathematics?
4. In thinking about your students' background, do you think that you can influence their students' achievement in mathematics despite their background?
5. Did the math cohort affect your confidence in your skills and abilities to teach mathematics effectively? If so, how? If not, why?
6. Is there anything else you would like to share regarding your experience while participating in the math cohort?

Thank you for your participation.