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Mathematics Curriculum Coaching and Elementary School Students' Mathematics Achievement in a Northeast Tennessee School System

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Mathematics Achievement in a Northeast Tennessee School System

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by

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ABSTRACT

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Educators and policymakers have demonstrated interest in finding ways to better equip mathematics teachers so they can help students achieve at a higher level. Academic coaching has been identified as an effective professional development activity for teachers. The purpose of this study was to investigate the difference between students' achievement levels before and after a mathematics initiative in a Northeast Tennessee school district. In this study I analyzed grades 3 – 6 students' Tennessee Comprehensive Assessment Program or TCAP scores in the year prior to the hiring of a mathematics coach and their respective scores 2 years after the placement of the mathematics coach. All statistical analyses were analyzed at a .05 level of significance. All null hypotheses under both research questions were analyzed with a pair-sampled t-test using repeated-measures design. The results indicate significant difference in students' TCAP scores prior to and after specialist. Scores after specialist were significantly higher than scores before specialists. The difference was present for students who attended Title I schools as well as for students who attended non-Title I schools. School administrators and school district leaders can benefit from such a study because it presents academic coaching as a viable means to equip teachers so they can help students increase their achievement in mathematics.

DEDICATION

This dissertation is dedicated to God, The Rev. Charles C. Alexander and his wife Ellen Alexander (in memoriam), my family, and my students. I thank God for having given me the ability and desire to learn and to persevere in whatever I undertake. The Rev. and Mrs. Alexander (my American parents) saw something in me that was worth their time and dedication when I was 10 years old in the slums of Fortaleza, Brazil. I will forever be grateful to them. They changed my life and many others with their kindness, compassion, and generosity. My wife and three children were a source of strength and inspiration throughout this process. They helped me stay focused on my goals. My students inspire me every day and give me motivation to improve my craft so that I can equip them to be successful citizens.

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CHAPTER 1

INTRODUCTION

Public and political interest in the quality of education afforded to students in the United States intensified in the last 40 years. The National Commission on Excellence in Education's *A Nation at Risk* report (NCEE, 1983) issued a harsh judgment on the quality of American education. The accuracy and interpretation of *A Nation at Risk's* findings have been questioned (Bracey, 2003). Notwithstanding its accuracy, the report called for immediate reforms. The accountability movement with its high-stakes standardized tests mandated by the No Child Left Behind (NCLB) Act of 2001 served to further heighten the interest in educational reform. Mathematics education in particular gained special attention due to the view of mathematics literacy as a required tool for national security and economic prosperity. Mathematics literacy has been considered a survival skill (Garfunkel, 2007). Furthermore, results from international metrics such as the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) showed mediocre performance level for American students when compared to students in other industrialized nations (Epstein & Miller, 2011; NCTQ, 2008; Ravitch & Cortese, 2009). The performance of American students in these international assessments further alarmed educators and policymakers.

Educational researchers (Darling-Hammond, 2000; Hattie, 2003) and groups such as the National Council of Teachers of Mathematics (NCTM, 2000) and the National Council of Teacher Quality (NCTQ, 2008) have asserted that student learning and student achievement closely relate to the experiences that teachers present them in the classroom. Policy makers and educational reformers used these findings to push for improved teacher quality at all levels. In an effort to address teachers' mathematical deficiencies, school systems across the country have concentrated efforts toward improving teacher quality. The use of mathematics coaches or specialists at the elementary school level has gained momentum as a possible solution to improve teacher quality.

Researchers have established many functions for mathematics specialists or coaches. Three of these functions have a direct effect on teacher knowledge and have the potential to influence student outcomes. Mathematics coaches can (a) affect change in teachers' instructional practices, strategies, perception, and beliefs about mathematics teaching (Bruce & Ross, 2008; Keller, 2007; Murray, Ma, & Mazur, 2009; Nickerson, 2009; Obara, 2010;); (b) assist in improving students' learning and achievement (Campbell & Malkus, 2011; Dobbins, 2010; Foster & Noyce, 2004; Vale et al., 2010); and (c) help teachers have a better understanding of curriculum (Harrison & Killion, 2007; Von Rotz, 2006; West & Staub, 2003).

This research surfaced from my desire to examine achievement levels of elementary school students when a mathematics specialist is put in place to work with elementary school teachers. In particular I analyzed the difference in mathematics achievement levels for elementary school students in grades 3 through 6 when a mathematics improvement initiative is implemented in a Northeast Tennessee school system.

Statement of the Problem

Research confirms that what teachers know and do make a difference in student achievement (Darling-Hammond, 2000). Therefore, it would seem important that schools and school systems explore ways to deliver appropriate professional development for their teaching force in order to increase student learning that ought to be the main focus of education.

Desimone (2009) documents that traditional professional development such as one-shot workshops and conferences do not address the needs of most teachers. Academic coaching has been identified as a very promising professional development activity. Coaching offers the characteristics of effective professional development such as content-specificity, sustainability, collaboration, and coherence.

In 2011 the school district hired a mathematics curriculum specialist as part of its mathematics improvement initiative to raise students' mathematics achievement. Thus there was no mathematics coach or specialist present in 2010 and by 2012 the specialist had been working with teachers in the system for 2 years. The mathematics coach who was hired was a middle school mathematics teacher who had been teaching in the system for 18 years; 10 years as a fifth grader teacher and 8 years in seventh grade. There was no special training offered to the coach at the time of hiring. The coach was an experienced classroom teacher who had been awarded recognition for excellence in teaching. The coach's training included a master's in K-6 mathematics teaching.

The coach responded to principals' and teachers' request for assistance. The coach assisted teachers with lesson design, organized and presented workshops for teachers, found diverse resources for teachers, scheduled guest speakers, and scheduled webinars that addressed mathematical content. The coach also observed teachers, cotaught with them, assisted with the design of benchmark tests and other assessments, and met with teachers to debrief them after coaching sessions. Time was not evenly divided among schools or even teachers. Teachers at Title I schools received more individual assistance than those who taught at non-Title I schools. Two of the five elementary schools were Title I schools and the only middle school was a Title I school.

The purpose of this study was to investigate the difference between students' achievement levels before and after a mathematics initiative in a Northeast Tennessee school district. Tennessee Comprehensive Assessment Program (TCAP) scores were used for achievement levels. A mathematics specialist serving as a coach was part of the mathematics improvement initiative. The study specifically focused on students in grades 3 through 6 in 2010 and the same students 2 years later, 2012. Students were included in this study if there were test scores for both years.

Research Questions

The following research questions were used to guide the study:

1. Are there significant differences in student achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP)?
2. Are there significant differences in student achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP) with regard to Title I or non-Title I schools?

Significance of Study

The ultimate goal of education is student learning. Teachers' knowledge and their classroom practices influence student learning. Although scarce, research on the effect of academic coaching on student achievement has grown in the last few years. This type of research serves to guide elementary school teachers as they seek ways to improve their effectiveness, school administrators who struggle to find ways to help their teachers grow, and school systems that look for better ways to provide meaningful professional development to their teachers. Coaching offers hope for a promising course of action. Academic coaching initiatives raise hope for student achievement in mathematics, an area of growing concern by mathematics educators and policy makers. The literature presented in this review suggests that elementary school teachers' mathematical content and pedagogical knowledge lacks depth and uniformity. A study of the effectiveness of mathematics coaching can serve to address these deficiencies in teachers' knowledge.

Definitions of Terms

The terms listed below appear frequently throughout this dissertation, especially in the review of the literature. Their definitions are intended to assist the reader in having a better understanding of this study.

1. Coaching – sustained classroom-based support from a qualified and knowledgeable individual who models research-based strategies and explores with teachers how to incorporate these practices using the teacher's own students (Sailors & Shanklin, 2010, p. 1).
2. Job-imbedded professional development – teacher learning that is grounded in day-to-day teaching practice and is designed to enhance teachers' content-specific instructional practices with the intent of improving student learning (Darling-Hammond & McLaughlin, 1995; Hirsh, 2009).

3. Mathematical pedagogical content knowledge – the knowledge it takes to teach a particular mathematical topic in a way that the topic and the reasoning surrounding it makes sense to a particular learner or a whole class based on what they currently know or do not know (Ball, 2000).
4. Pedagogical content knowledge – the knowledge that goes beyond knowledge of subject matter per se into the dimension of subject matter for teaching. It includes the most useful forms of representing ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that makes it comprehensible to others (Shulman, 1986, p. 9).
5. Standard-based mathematics teaching – teaching toward specific skills, concepts, and knowledge students should learn at each grade level. It also focuses on research supporting the most effective teaching strategies for student learning. It refers to the standards developed by NCTM for mathematics teaching and learning (Bruce & Ross, 2008, p. 366).
6. Tennessee Comprehensive Assessment Program (TCAP) – a criterion- referenced assessment system designed to measure concept, processes, and skills taught throughout the state using a series of interconnected assessment (TB/McGraw-Hill, 1996).

Limitations and Delimitations

The participants in this study were delimited to grades 3 through 6 elementary school students in a school system in Northeast Tennessee. Students in the study took the regular TCAP assessment. Those who took modified TCAPs were not included in the study. Although the research shows promise in addressing teachers' mathematical deficiencies and increasing student achievement, several limitations must be noted. The study did not analyze how the coaching practices were implemented, the time spent by the specialist with each individual teacher, how the coach interacted with the teachers, how teacher prior knowledge and beliefs interfered with coaching experience, how teachers' pedagogical style and classroom practices changed because of coaching, and how the teachers and school administrators viewed the role of the coach. These types of data must be studied in order to have a better understanding of the effectiveness of peer coaching process. Furthermore the study did not include measures controlling for the degree to which teachers grew professionally through other routes of professional development such as summer workshops, university courses, school-based professional learning communities, and self-directed growth. These measures need to be addressed in order to have a clearer understanding of the benefits of academic coaching. Thus, the findings of this investigation may or may not be repeated in other settings.

Overview of the Study

This quantitative study is organized in five chapters. Chapter 1 includes a brief introduction and historical perspective of the developments in mathematics teaching in the United States, the problem statement, the research questions that guide the study, the significance of the study, definitions of key terms, and limitations and delimitations of the study. Chapter 2 presents a review of the relevant literature that addresses mathematics teaching in the United States, the preparation of elementary school mathematics teacher and the potential benefits of the use of mathematics coaches or specialists in increasing teacher knowledge and student achievement. Chapter 3 includes the population, research design, data collection procedures, and the methods used to analyze the data. Chapter 4 presents the analysis of the data and the results of the study. Finally, in Chapter 5 I present the conclusions of the study, a summary of the findings, and recommendations for further investigations.

CHAPTER 2

REVIEW OF LITERATURE

"Mathematics is the Queen of the Sciences." Carl Friedrich Gauss

"The advancement and perfection of mathematics are intimately connected with the prosperity of the state." Napoleon I

Perhaps no single academic subject has received more public attention in recent years than mathematics. There is growing concern that American students are not mathematically prepared to compete in an ever-increasing global economy and mounting fear that countries such as China and Japan will overtake America as the major economic force because their youth receive better education than ours, especially in mathematics. Concerns about mathematical education "is not simply about economic competitiveness or getting higher scores on international comparisons, rather it is about equipping our children with the necessary tools to be effective citizens and skilled members of the workforce in the 21st century" (Garfunkel, 2007, p. 186).

This literature review describes the progress of mathematics education in the United States from colonial times to the present. In it I present mathematics' rise from being relegated to night school during colonial times to the position of distinction that it currently enjoys. I also examine the literature that describes elementary school teachers' mathematical preparation in the United States and abroad and the literature that presents mathematics coaching as a plausible means to increase the mathematical knowledge of elementary school teachers that can lead to student achievement.

History of Mathematics Education in the United States

Educating children in the United States can be traced back to colonial times and the founding of the common schools of New England. In 1642 Massachusetts enacted a law requiring the instruction of children in reading, religious education, and a trade. Saracho and Spodek (2009) stated that reading and writing served to equip children to read the Bible and train them in moral values. In 1647 the old deluder Satan law in Massachusetts required that every town of 50 families provide an elementary school teacher and every town of 100 families provide a Latin Grammar school. One teacher taught children of all ages in these one-room schoolhouses. Arithmetic did not make its way into the schools until the middle of the 19^{th} Century. Teachers at special school, called reckoning schools, taught arithmetic applied to trade in the evenings once or twice a week (Jones & Coxford, 1970). The Latin Grammar school prepared students to enter Harvard College in order to train for the ministry, law, or to teach Latin.

After the American Revolution schools became more secular. Schools concentrated on teaching reading, writing, and arithmetic (the 3 Rs), building nationalism, training good democratic citizens, and improving society (Spring, 2011). The main methods of teaching were direct instruction and recitation. Teachers' training included diverse topics and those who had a working knowledge of fractions and proportions were considered exceptional teachers (Jones & Coxford, 1970). Mathematics instruction focused entirely on rote memorization of arithmetic with emphasis on counting and the operations of addition and subtraction (Saracho & Spodek, 2009). In arithmetic teachers stated a rule, worked examples, and assigned problems (Jones & Coxford, 1970).

The second decade of the 19th Century brought the development of the several initiatives that emphasized teaching of mathematics to children as young as 18 months using concrete materials instead of rote memorization to learn basic arithmetic concepts. The children's arithmetic of 1818 by Samuel Goodrich, mental arithmetic of 1821 developed by Warren Colburn, and the founding of the kindergarten by Friedrich Froebel in 1837 in Germany and adopted by educators in the United States are examples of educational programs that taught arithmetic to young children through natural and concrete methods (Saracho & Spodek, 2009).

The first part of the 19th Century saw the beginnings of formal teacher training. Massachusetts founded the first public normal school in 1839. In 1839 New York University established formal teacher training programs. Brown University in 1850 and the University of Michigan in 1860 also instituted teacher training (Jones & Coxford, 1970). In the beginning of the 20th Century the teaching process of stating the rule, presenting examples, and assigning work in arithmetic began to be replaced by discovery type processes.

The classical curriculum that emphasized Greek, Latin, and mathematics had a large influence in college and secondary education in the United States until the end of the 19th Century. These disciplines played an integral part of the widely accepted theory of "mental disciplines" (Roberts, 2001). Mathematics educators such as Jacob William Albert Young, Charles William Eliot, president of Harvard from 1869 - 1909, David Eugene Smith, and Isaac J. Schwatt held that mathematics contributed to the strengthening of the mind (Stanic, 1986b). A further belief involved the mental exercises applying to other fields of endeavors; that is, there was transferability to other domains of human activities (Lemire, 2002). At the end of the 19th Century, however, the theory of mental disciplines came under heavy attack from psychologists and educators alike. Edward L. Thorndike's experiments dealt a considerable blow to the theory of mental discipline (Klein, 2003).

Thorndike (1924) conducted a study with 8,564 high school students to test the theory of mental disciplines. He tested them in May of 1922 and retested the same students in May of 1923. In his conclusions, Thorndike stated:

> By any reasonable interpretation of the results, the intellectual values of studies should be determined largely by the special information, habits, interests, attitudes, and ideals which they demonstrably produce. The expectation of any large difference in general improvement of the mind from one study rather than another seems doomed to disappointment. The chief reason why good thinkers seem superficially to have been made such by having taken certain school studies is that good thinkers have taken such studies, becoming better by the inherent tendency of the good to gain more than the poor from any study. When the good thinkers studied Greek and Latin, these studies seemed to make good thinking, Now that the good thinkers study Physics and trigonometry, these seem to make good thinkers. If the abler pupils should all study Physical Education and Dramatic Art, these subjects would seem to make good thinkers. …After positive correlation of gain with initial ability is allowed for, the balance in favor of any study is certainly not large. (p. 98)

Progressivist Education

The progressivist movement led by educators like John Dewey and William Heard Kilpatrick dominated mathematics education in the beginning of the 20th Century (Klein, 2003). The progressivist movement emphasized child-centered, discovery-type of experiences, guided by utilitarian purposes. In fact, Klein (2003) stated that Kilpatrick rejected the idea that mathematics education contributed to mental discipline, one of the strong points for those who argued for the teaching of mathematics in schools. He advocated that subjects should be taught only based on utilitarian value such as finding areas and converting units of measures (Findell, 2001). According to Klein (2003), Kilpatrick recommended that algebra and geometry be removed from the high school curriculum except "as an intellectual luxury." Kilpatrick maintained that mathematics was more "harmful rather than helpful to the kind of thinking necessary for ordinary living" (p. 4). The result was a reduction in mathematical content in schools.

Progressivist ideas about education drew support from Thorndike's theory of learning. Thorndike posited that instruction should engage in practical social goals. He also proposed that learners should construct their own learning rather than being instructed by a teacher (Klein, 2003). Progressivists, in particular Dewey, called for teachers to be coworkers with pupils and serve as guide for students in their personal learning rather than serving as task master who bestowed knowledge and assigned and lead drill and practice (Arthurs, 1999).

Swiss philosopher Jean-Jacques Russeau's work had a considerable influence on Dewey's philosophy. Russeau's most important book on education, *Émile*, related a story of a child taken from civilization and raised in the country. *Émile* had a private tutor who instructed him through natural experiences. Russeau believed that children's natural interest, their psychological, physiological, and social development should guide their education. In *Émile*'s education, book learning was not introduced until he was 12 years old. Russeau's writing about learning derived from experiences influenced several other prominent educators such as Johann H. Pestalozzi, Friedrich Froebel, and Maria Montessori (Ozmon & Craver, 2012). Russeau's writing influenced the way educators thought about children. Educators saw children as individuals going through stages of development who needed educational experiences that addressed their natural development.

The activity movement of the 1930s, largely influenced by the writings of Kilpatrick, supported the combination of subjects in elementary schools and the elimination of instruction in mathematics and other subjects. Soon the movement spread throughout elementary schools in the country. The movement had little success at high schools because teachers who were specialized in their content areas did not want to renounce their subjects in favor of the holistic education proposed by the movement (Klein, 2003).

In 1940, even though there was heavy criticism by the military about the lack of basic mathematics skills of its recruits, a new education movement called life adjustment surfaced from the education community. The life adjustment movement claimed that schools were too focused on academics and not enough on life skills. Proponents of the movement claimed that most students did not have the intellectual ability to go to college or even to be skilled workers. They needed skills for daily living such as buying, reading maps, and home budgeting, but not algebra, geometry, or trigonometry (Klein, 2003).

As a result of progressive education with its child-centered, discovery-type of learning, utilitarian philosophy, and less emphasis on academic subjects such as mathematics, enrollment in algebra and geometry declined during the first half of the 20th Century (Stanic, 1986a), as shown in Table 1.

Table 1

Percentages of U.S. High School Students Enrolled in Algebra and Geometry

School Year	Algebra	Geometry
1909 to 1910	56.9%	30.9%
1914 to 1915	48.8%	26.5%
1921 to 1922	40.2%	22.7%
1927 to 1928	35.2%	19.8%
1933 to 1934	30.4%	17.1%
1948 to 1949	26.8%	12.8%
1952 to 1953	24.6%	11.6%
1954 to 1955	24.8%	11.4%

Note: Data adapted from Jones & Coxford (1970, p. 54).

New scientific and technological breakthroughs of the late 1940s such as the appearance of the radar, cryptography, and the advances in atomic energy promoted economic changes in the country and accentuated the need for mathematics for a changing world (Findell, 2001). Progressive education came under heavy criticism from educators in the 1950s, and it went into retreat giving rise to the new math movement (Findell, 2001; Herrera & Owens, 2001).

New Math of the 1960s

Concerns after WWII that students were not prepared to keep up with the developments of the new technological age, the need for scientists and mathematicians, events in the international scene, and dissatisfaction of both the public and mathematicians with the mathematics preparation of high school students in the United States served to initiate the new math movement in education (Findell, 2001; Herrera & Owens, 2001; Kilpatrick, 1997; Woodward, 2004). The launching of the satellite Sputnik into orbit by the former Soviet Union in October of 1957 created the perception that the United States was falling behind in comparison to other global powers. Many associate the launching of Sputnik as the event that gave impetus to the new math reform movement (Findell, 2001).

The new math movement promoted changes in curriculum at the high school, junior high, and elementary level. The University of Illinois Chicago for School Mathematics (UIC-SM) introduced a high school curriculum with an integrated approach that included algebra throughout the 4 years of high school mathematics, the introduction of set theory, and an overall emphasis on discovery learning and teaching (Kilpatrick, 1997). Another influential group, The School Mathematics Study Group (SMSG), advocated mathematics teaching that prepared students for college mathematics. SMSG proposed the teaching of inequalities together with equation, proofs in algebra, integrated plane and solid geometry with coordinate geometry, integrated algebra and trigonometry, and a course in basic functions (Herrera & Owens, 2001).

The University of Maryland Project, SMSG, and the Madison project were the main initiative for junior high mathematics. These projects emphasized precise mathematical language, logic, mathematical systems, geometry and its applications, measurement, and statistics. These topics at the junior high school level intended to prepare students for the high school curriculum (Herrera & Owens, 2001).

Changes in the curriculum at the elementary level also developed. Teachers had more difficulty implementing these changes because most elementary school teachers were not mathematics specialists. At the elementary level students began to study set theory, algebraic properties, and bases other than 10. Teachers implemented changes in geometry, but other topics such as graphs, algebra, and statistics were more difficult to implement due to the teachers' lack of understanding of these topics. Little mathematics in-service training was offered (Herrera & Owens, 2001).

Professional mathematicians with little or no knowledge of pedagogy or child development developed the new mathematics curriculum (Findell, 2001). As a result teachers, students, and parents criticized the new curriculum. Parents felt frustration at their inability to understand the new math and help their children with their school work. By the beginning of the 1970s new math came under attack for several reasons: over-emphasis on theory, pure instead of applied mathematics, high level of abstraction, emphasis on deductive reasoning, the formal language of set theory and proofs, and the abandonment of basic computational skills. A new movement, "back to basics" which emphasized basic computations and algebraic manipulation, was starting to gain public support (Herrera & Owens, 2001).

Back to Basics

The back to basics movement of the 1970s grew out of the adult dissatisfaction with math teaching. Furthermore, political, religious, and business leaders disdained the quality of education offered to American children at the elementary and secondary schools. The movement did not have a single unifying theme across the country but, at its core, there was a call for emphasis on drill and practice of reading, writing, and arithmetic (Woodward, 2004). In some instances the movement also called for schools to instill patriotism and moral values. Brodinsky (1977) listed several factors that contributed to the advent of the back to basics revolution. Among these factors were (a) parents did not like or understand the policies in schools and they tried to reshape them according to their views, (b) African-American and Hispanic parents claimed that their children did not receive appropriate instruction in basic skills, (c) confusion on the part of educators about how to combine basic skills with demands to create independent thinkers, (d) complaint by employers that students were not being prepared to be productive workers, (e) institutions' of higher education complaints that high school graduates lacked fundamental skills to be successful in colleges, (f) reports that claimed to show a drop in achievement scores for American students, and (g) the perception that achievement scores had dropped because schools were not challenging students.

In mathematics back to basics called for drill of basic arithmetic skills and less emphasis on abstraction and concepts, trademarks of the new math reform. At all grade levels the primary method of instruction should be direct instruction given by teacher with plenty of drill, daily homework, and frequent testing. Innovations, such as discovery, student-directed learning should be eliminated from schools altogether (Woodward, 2004). The effective way of presenting lessons were to conduct a brief review, present the new material, allow time for independent practice, and assign homework.

Although school boards realized that their students should be proficient in reading, writing, and arithmetic, many of them moved slowly to formally adopt basics philosophy, mainly because of the large amount of restructuring that would be necessary. Brodinsky (1977) related that in response to the back to basics movement some school districts introduced proficiency testing to measure minimum competencies of its students at different stages in the school career. Oakland, California schools required their high school students to pass proficiency tests in reading, writing, and computation. The state of Florida enacted laws requiring proficiency testing at grades 3, 5, 8, and 11. By 1977 Florida had established laws that students who did not achieve proficiency were not socially promoted and by 1978 the state had established proficiency levels for its high school graduates. Students who did not achieve proficiency received remediation, and diplomas were awarded based on the levels of achievement of the graduates.

By the end of the 1970s educators showed their dissatisfaction with back to basics teaching. Although students showed mastery of computational skills in the four operations of addition, subtraction, multiplication, and division, they did not have the understanding of when to use these operations (Findell, 2001). The publication of papers by the National Council of Supervisor of Mathematics (NCSM, 1977) identifying 10 basics skills needed in mathematics, the release of the National Council of Teachers of Mathematics' (NCTM, 1978) position paper concurring with the NCSM's views, and the NCTM's publication of *An Agenda for Action* (NCTM, 1980) proposing more emphasis on problem-solving skills in mathematics teaching gave rise to a new movement in mathematics education. The publication of *A Nation at Risk* (National Commission on Excellence in Education, 1983) intensified criticism of the back to basics reform. The report stated, "if an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war" (p. 5). *A Nation at Risk* gave rise to the federal government's heavy influence on educational matters, albeit its influence on curricular practices have been questioned (Hewitt, 2008) and its findings have been suspect of serving as propaganda and being inaccurate and untrustworthy (Bracey, 2003). Despite disagreements over the report's findings, its publication had a major impact in ushering the standards movement. In 2001 with the reauthorization of the Elementary and Secondary Educational Act of 1965 the No Child Left Behind (NCLB) Act required that all states develop challenging academic content standards for subjects determined by the State but including mathematics, reading or language arts, and science. Science standards were required by the 2005-2006 school year (p. 21).

Standards-Based Reform Movement

The discontentment of educators with the curricular focus and pedagogical approach of back to basics with strong support from the leadership of NCTM served as the thrust for the standards movement (Kilpatrick, 1997). At the elementary level there was strong emphasis on computation skills with little or no emphasis on problem-solving skills (Herrera & Owens, 2001). In mathematics classes around the country the routine was the same with teachers going over assignment from the previous day, lecturing on new material, allowing time for student practice, and assigning homework. While students worked, teachers walked around the room answering questions (Herrera & Owens, 2001). Educators expressed concerns that new advances in mathematics and technology such as computers and calculators that were being integrated into society were not making their way into the classrooms.

In *An Agenda for Action* (NCTM, 1980) the council called for mathematics curriculum with these adaptations mandates:

- Problem solving be the focus of school mathematics in the 1980s;
- Basic skills in mathematics be defined to encompass more than computational facility;
- Mathematics programs take full advantage of the power of calculators and computers at all grade levels;
- Stringent standards of both effectiveness and efficiency be applied to the teaching of mathematics;
- The success of mathematics programs and student learning be evaluated by a wider range of measures than conventional testing;

- More mathematics study be required for all students and a flexible curriculum with a greater range of options be designed to accommodate the diverse needs of the student population;
- Mathematics teachers demand of themselves and their colleagues a high level of professionalism; and
- Public support for mathematics instruction be raised to a level commensurate with the importance of mathematical understanding to individuals and society. (p. 6)

NCTM followed its *Agenda for Action* with its C*urriculum and Evaluation Standards for School Mathematics* (1989), *Professional Standards for Teaching Mathematics* (1991), and *Assessment Standards for School Mathematics* (1995). These three documents, commonly known as *The Standards*, lay the foundation for mathematics teaching and learning in grades K-12 in the United States in the standards era. The publication of the NCSM's *Essential Mathematics for the Twenty-First Century* (1989), the National Research Council's report *Everybody Counts* (NRC, 1989) which recommended that a core of mathematics be taught to all students rather than just a few, and other documents from the mathematical community made it clear the call for reform in mathematics teaching (Findell, 2001) and gave support to the NCTM's *Standards*.

The Curriculum Standards outlined the mathematical topics that should be taught at the elementary (K-4), intermediate (5-8), and secondary (9-12) levels. It also recommended that the various disciplines of mathematics be connected to one another and other disciplines and that mathematics be presented as a reasoning process, a problem-solving tool, a way to communicate solutions, and a tool applicable to real-life situations (NCTM, 1989). *The Standards* were revised in 2000 further expanding on the original *Standards.* The curriculum was further reorganized into four grade bands: prekindergarten through grade 2, grades 3–5, grades 6–8, and grades 9–12 (NCTM, 2000).

The *Professional Standards for Teaching Mathematics* (NCTM, 1991*)* presented standards for the teaching of mathematics, the evaluation of teaching of mathematics, professional development of teachers of mathematics, and the support needed for these reforms. It was recommended that teaching move from teacher-centered to student-centered teaching. The standards recommended that teachers design worthwhile and meaningful tasks for students, promote mathematical discourse in the classroom, create a classroom environment that promotes mathematical engagement of all students, and monitor classroom to obtain information on how to plan and improve instruction.

Standards-based mathematics teaching with its call for emphasis on problem-solving, the communication of mathematical ideas, the role of the teacher as a orchestrator of dialogue, high level of student engagement, use of various technologies such as calculators, computers, and manipulatives, and an environment that fosters student growth differed vastly from the experiences that most teachers experienced as students (Lubinski & Otto, 2004). Research demonstrated that most teachers teach the way they were taught. Thus, schools, school systems, and teacher preparation programs had to address the needs of in-service and preservice teachers if standard-based teaching was to be expected from teachers.

Teacher Preparation

Teachers play an important role in student learning and achievement. Research has demonstrated that teachers who possess content knowledge, understand different pedagogies, display varied teaching skills, are adaptable and creative, and promote active learning positively affect student learning (Darling-Hammond, 2000, 2005, 2007; Darling-Hammond & Baratz-Snowden, 2007; Hill, Rowan, & Ball, 2005; Schmidt, 2012). The NCTM's (2000) *Principles and Standards for School Mathematics* also indicated the importance of teachers in the learning process. The *Standards* unmistakably maintained that in order to be effective mathematics teachers must have deep knowledge of the mathematics they teach, must know their students, need to be versatile in their pedagogy, and be reflective and deliberate about their practice.

Teacher quality in the United States, especially in mathematics, has been closely scrutinized in part due to the weak mathematical performance of American students when compared to students in other industrialized nations in assessments like Trends in International Mathematics and Science (TIMSS) and the Program for International Student Assessment (PISA). In 2003 the United States ranked 28 out of 40 nations in mathematics achievement (Darling-Hammond, 2007). This underperformance persisted on the 2009 PISA and more recently TIMSS (Epstein, & Miller, 2011). Concerns with teacher quality influenced efforts at the federal level with NCLB (2001) Act that required that elementary and secondary school teachers be highly qualified by no later than the end of the school year of 2005-2006. A highly qualified teacher typically has a bachelor's degree, holds a state certification, and must demonstrate competence in the subject(s) that he or she teaches (NCLB, 2001).

Although there is considerable research evidence that link student achievement to what teachers know and do in the classroom, scholars have not agree about the best way to prepare teachers for the work they do (Hattie, 2003; National Council on Teacher Quality [NCTQ], 2008). Teacher preparation paths have varied widely from state to state (Darling-Hammond, 2000; Darling-Hammond & Baratz-Snowden, 2007). Most teachers who enter classrooms in the United States receive a formal undergraduate teacher education at a traditional college or university but, increasingly, teacher candidates pursue other paths, especially teachers who end up teaching in high-demand urban, low-income, and high-minority population areas of the country (Darling-Hammond, 2007; Darling-Hammond & Baratz-Snowden, 2007; NCTQ, 2008; Schmidt et al., 2007). Ironically, those who need the best teachers receive the least qualified ones, thus creating a wider achievement gap (Darling-Hammond, 2007).

In a comprehensive 6-year long study of a large data set from schools in Houston, Texas, Darling-Hammond, Holtzman, Gatlin, and Heilig (2005) found that fourth and fifth graders instructed by fully certified teachers performed at significantly higher levels in six different reading and mathematics tests, than students taught by uncertified teachers. Texas grants full certification upon completion of rigorous preparation in an approved teacher education program, satisfactory performance in a battery of tests that include content knowledge, pedagogical knowledge, mathematics, and communication skills.

In a meta-analysis of more than 500,000 studies on the effect of variables on student achievement Hattie (2003) determined the existence of six major sources in variance in student achievement. Of these variables, teachers contribute 30% toward student achievement. Teachers have a greater influence on student achievement than the home, schools, principals, and peers. Teacher influence has less impact only when compared to the characteristics of the student (ability level, motivation, etc). What teachers know, do, and believe have a powerful influence on achievement.

What Elementary School Mathematics Teachers Need to Know

Although still lacking, research about what mathematics elementary teachers need to know and do to be effective has grown in recent years, but it is not certain that teachers have access to the existing knowledge about teacher effectiveness (Darling-Hammond & Baratz-Snowden, 2007). However, consensus has not emerged about the type of mathematical knowledge needed by elementary teachers (Ball, Lubienski, & Mewborn, 2001). The differences between research and practice can be partly attributed to the different paths taken by those who end up teaching our youth and the quality of those paths (Darling-Hammond & Baratz-Snowden, 2007). Even though most individuals who enter the teaching professional do so through formal teacher preparation in either a 4-year undergraduate or 5-year graduate program, a large number of candidates enter the teaching ranks through alternate paths where the quality of preparation varies tremendously (Cochran-Smith, 2005; Darling-Hammond & Baratz-Snowden, 2007; NCTQ, 2012). The type and quality of teacher preparation at the various conventional education schools across the country vary considerably. NCTQ (2008) reported that only 13% of a sample of 77 education programs at colleges and universities stood out for their quality in mathematics preparation (p.31). To further blur the picture, teacher candidates bring with them a variety of backgrounds and beliefs about teaching that contribute positively or negatively to the way they will behave in the classroom (Gresham, 2007; Kajander, 2010). With so many variables to consider, no single method of teacher preparation seems to be optimal.

Research (Anstey & Clark, 2010; Darling-Hammond & Baratz-Snowden, 2007; Hill et al., 2005) has demonstrated, however, that there are some basic requirements that all teachers should be expected to have before there are allowed to practice on their own. These requirements encompass a basic knowledge of learning theories, an understanding of the content and curriculum they will teach, a comprehension of developmental theory, and fluency with pedagogical practices. Anderson and Kim (2003) identified another type of knowledge called mathematical pedagogical content knowledge as key to effective mathematical teaching.

Mathematical pedagogical content knowledge is a complex set of skills. It involves knowing the learner, understanding the topics that present the most challenge for learners, designing lessons and activities that help learners understand difficult concepts, addressing misconceptions, and at the end, leading the learner toward understanding.

Chapman (2012) suggested that teacher preparation programs should address teachers' prior beliefs and attitudes toward mathematics, especially when they are expected to implement reform-oriented curricula. In a study conducted with three experienced teachers in the second year of implementation of a problem-based mathematics curriculum, Chapman and Wood (2004) observed that teachers' dispositions toward problem-based teaching influenced implementation of the curriculum. Teachers viewed that problem-based teaching would be more meaningful to students, but they showed less enthusiasm about the use of groups in their teaching. Thus, they did not prioritize grouping students in their teaching. Lubinski and Otto (2004) also reported on teachers' attitudes, perceptions, and beliefs in a study conducted with 16 prospective K-8 mathematics teachers who had enrolled in a mathematics content course designed to prepare teachers to implement standard based mathematics teaching. In particular, the authors presented evidence that prior beliefs interfered with learning of mathematics and the implementation of reform-based curriculum. The authors demonstrated with data from a pre- and posttest that prospective teachers changed their views about the meaning of learning and teaching mathematics.

Several groups have made recommendations regarding the mathematical knowledge that elementary school teachers should possess and how to accomplish their mathematical preparation. The recommendations include:

- In 2001 the Conference Board of the Mathematical Sciences recommended that prospective elementary teachers take at least 9 semester hours on fundamental ideas of elementary mathematics, in numbers and operations, algebra and functions, geometry and measurement, and data analysis, statistics, and probability;
- In July 2005 the NCTM issued a position statement that elementary teachers should have completed the equivalent of at least three college-level mathematics courses that emphasize the mathematical structures essential to the elementary grades (including numbers and operations, algebra, geometry, data analysis, and probability);
- The National Mathematics Advisory Panel in 2008 issued a policy recommendation that the mathematics preparation of elementary school teacher should be strengthened with ample opportunities to learn mathematics for teaching. Teachers should have detailed knowledge of the mathematics both prior and beyond the level they teach; and
- NCTQ recommended five standards for the mathematical preparation of elementary school teachers. These standards provide the necessary guidelines that address the need for teachers to acquire a detailed, conceptual understanding of elementary and middle school mathematics topics, as well as essential pedagogical training. NCTQ standards recommended that (a) teachers learn mathematics not as a set of procedures but at the conceptual level, (b) admittance requirement for education schools be more rigorous, (c) tougher exit requirements be put in place at education programs, (d) mathematics methods and content

courses be more closely aligned and administered in a way that allows for supervised practical experiences, and (e) that mathematical content be taught by the mathematics department of the school of education (NCTQ, 2008, pp. 11-12).

NCTQ (2008) also listed critical areas and the amount of time dedicated to each area in teacher preparation programs. They are: numbers and operations, 40 hours; algebra, 30 hours; geometry and measurement, 35 hours; and data analysis and probability, 10 hours. NCTQ (2008) further documented the findings of a study of 257 syllabi and required texts in 77 undergraduate education programs in 49 states and the District of Columbia that investigated whether the courses offered by these programs adequately prepared elementary school teachers in kindergarten to fifth grade to teach mathematics. The findings revealed that:

- Few education schools cover the mathematics content that elementary teachers need. Most programs neglected teaching algebra;
- Most states do not agree on the requirements needed for mathematics preparation of elementary school teachers;
- Most textbooks used by the schools have inadequate content for the mathematical preparation of elementary school teachers;
- Schools have extremely low entrance requirements for candidates into elementary school teaching programs. Almost anyone can be accepted into these programs;
- Exit exams are just as low as the requirements for entrance into these programs.
- Mathematics methods coursework do not emphasize elementary mathematics. Practice offered at methods courses, when offered, lacks quality;
- Most of the time the instructors of mathematics to elementary teacher candidates lack qualification to do so; and

- Mathematics courses at most schools do not offer rigor in content and do not have high expectations of students. (NCTQ, 2008, pp. 23-47)

Research data support the claim that elementary school teachers' mathematical knowledge and preparation are weak and inadequate to achieve the level of student learning desired by reform mathematics curriculum (Ball, 1996; Darling-Hammond, 2000; Epstein & Miller, 2011; Kulm, 2008; NCTQ, 2008, 2012). The ineffectual mathematical preparation of elementary school teachers occurs across the states. In its annual *Improving Teacher Preparation, State Teacher Policy Yearbook*, NCTQ (2012) noted that only one state, Massachusetts, ensures that its elementary school teachers receive appropriate training in mathematics. Elementary school teachers in Massachusetts receive instruction in conceptual mathematical knowledge as well as in the mathematics they will be required to teach. In addition, teaching candidates must pass rigorous exit exams before they acquire full certification (p. 6).

In its report NCTQ (2012) identified Tennessee along with Alabama, Florida, and Indiana as states that have shown improvement over the past years in their efforts to improve teacher preparation and licensing requirements. However, the report pointed out that Tennessee has deficiencies in requiring that teacher preparation programs provide mathematics content specifically geared to the needs of elementary teachers (p. 125). Table 2 depicts the required mathematics courses for three elementary teacher preparation programs in Northeast Tennessee: (a) King University; (b) Milligan College; and (c) East Tennessee State University. The requirements vary from a minimal of one course plus student teaching at Milligan College to more advanced mathematics at East Tennessee State University.

Table 2

Required Math Courses for Prospective Elementary School Teachers at Local East Tennessee Teacher Preparation Programs

King University	Milligan College	ETSU
MATH 1230 – Precalculus	MATH 253 - Fundamental concepts	Select 3-4 hrs from: MATH 1530 -Probability and statistics- noncalculus (3 hrs.)
MATH 1560 - Introduction to statistics	EDUC 451- Student teaching	MATH 1840 - Analytical geometry and differential calculus (4 hrs.)
MATH 2200- Mathematics for elementary teachers		MATH 1910 - Calculus I (4 hrs.)
EDUC 4470 Student teaching: K-Grade 4		and
		MATH 1410 – Number concepts and algebraic structures
		and
		MATH 1420 – Logic, problem solving and geometry
		and
		CUAI 4310- Residency I: mathematics

Note: The information was gathered from King University, ETSU, and Milligan College Web site.

Teacher Preparation Abroad

Most industrialized nations or nations that have impressive academic achievement in international assessment like TIMSS and PISA have made considerable investment in their teacher workforce (Darling-Hammond, 2007; Gonzales et al., 2004). Many Europeans and Asian countries have more demanding teacher preparation programs, pay higher salary to their teaching force, invest in building teacher capacity, and provide more coherent professional development for in-service teachers (Darling-Hammond, 2005). Beginning in the late 1980s many high performing countries including Germany, France, Finland, Japan, and Taiwan have implemented teacher preparation as a graduate degree. These degrees include intense pedagogical content and practical experiences in addition to strong content-specific preparation at the undergraduate level before the teacher is allowed to step into a classroom on his or her own (Darling-Hammond, 2005; Hargreaves & Shirley, 2009).

It has been argued that elementary mathematics teachers in other nations have stronger mathematical content knowledge than their counterparts in the United States (Ma, 1999). Several reasons are given for this gap in mathematical knowledge between elementary teachers in the United States and abroad. For instance, in South Korea, Finland, Singapore, and Hong Kong, countries that consistently outperform the United States in mathematics achievement, teacher candidates are usually selected from the top of their cohorts (Epstein & Miller, 2011). This selection process does not take place for teacher candidates in the United States (NCTQ, 2102).

Ma's (1999) study that compared mathematical knowledge of Chinese teachers with their American counterparts combined with Chinese students impressive achievement in mathematics has triggered a growing interest in Chinese teacher preparation, especially at the elementary level (Li, 2008). An apparent difference between Chinese elementary school teachers and teachers in many other educational systems around the world is that Chinese elementary school teachers are content specialists (Li, 2008). They prepare to teach many subjects, but once they are assigned to a school they focus on teaching one main area, especially if it is Chinese or mathematics (Li, Zhao, Huang, & Ma, 2008).

Li et al. (2008) listed three kinds of preparation for elementary school teachers in China: (a) 3-year preparation at a normal school that admits middle school graduates; (b) a 3- or 5-year normal school that admits middle and high school graduates; and (c) 4-year BA or BS offered at normal schools or universities. The 4-year BA or BS has become increasingly more popular. Within the 4-year option three possible paths can be pursued by teaching candidates: integrated, focus area specific, and middle ground. No matter the path, however, there is a strong emphasis in mathematics preparation of prospective teachers. Li et al. (2008) outlined a typical curriculum for the three paths. The integrated approach contains advanced mathematics, theories of elementary mathematics teaching and learning, methods of mathematical thinking, and psychology of mathematics learning. The focus-area path requires theories of elementary math curriculum and instruction, mathematical analysis I, advanced algebra I, advanced algebra II, analytical spatial geometry, elementary number theory, mathematical analysis II, probability and statistics, mathematical thinking methods, in addition to 13 hours of electives in mathematics. Finally the middle-ground path requires 34 credits in mathematics that must include mathematical analysis, linear algebra, analytical geometry, probability and statistics, mathematical thinking methods, and mathematical game and competition. All three paths require field experience varying from 5 to 14 weeks.

Teacher preparation in other countries, especially in countries whose student perform well on international assessment, can shed some light on the path of teacher preparation in the United States. But, schools systems across the country have adopted other paths to improve the quality of their teaching force. The placement of academic coaches or specialists serves as a promising alternative to improve teacher quality, particularly in mathematics.

Mathematics Coaches or Specialists

Schools and school systems across the country have turned to the placement of mathematics coaches or specialists in elementary schools as a way to improve mathematics instruction and to increase student achievement. The practice of placing academic coaches in schools has become a common practice in many K-12 schools, especially in literacy, mathematics, and science (Sailors & Shanklin, 2010). Teachers' learning and continuous growth have been identified as paramount to improving the quality of education offered to all students (Darling-Hammond, 1993, 2000; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2011; Hattie, 2003). The NCTM's *Principles and Standards for School Mathematics* asserted that student learning depends on the experiences that teachers present them in the classroom (NCTM, 2000). Thus, teachers must understand mathematical content in order to design experiences that support students' learning. The placement of specialists in elementary schools serves as a means of providing job-imbedded professional development experiences for teachers so they can acquire the resources needed to improve their mathematical knowledge and pedagogy, as recommended by the NCTM (2000). Many teachers report their willingness to try different practices and strategies if they are supported by and collaborate with a colleague in the process (Kohler, Crilley, & Shearer, 1997). Subsequent to an observation of 14 high school mathematics teachers in California, Becker and Pence (1999) maintained that classroom coaching endeavor takes time and requires financial commitment, but they also identified coaching as an essential piece in providing effective professional development for teachers. Kohler, Ezell, and Paluselli (1999) also stated that, despite considerable investment of time, effort, and resources, whenever school systems embark in peer coaching activities there are clear benefits from peer coaching professional development.

Peer coaching model of professional development allows for learning that is: (a) content-specific; (b) requires active participation of coach and teacher; (c) addresses specific school district and state learning objectives (standard-based learning); (d) can be sustained over a period of time; and (e) requires a high degree of collaboration from participants. These five characteristics have been identified by researchers as necessary for effective professional development that promotes teacher growth and has the potential to positively affect student achievement (Desimone, 2009, 2011; Jeanpierre, Oberhauser, & Freeman, 2005; Johnson, Kahle, & Fargo, 2007; Penuel, Fishman, Yamaguchi, & Gallagher, 2007).

The concept of coaching as a means of professional development is not a recent phenomenon. Sailors and Shanklin (2010) noted that the term appeared in the literature about 80 years ago. Joyce and Showers (as cited by Chval et al., 2010) introduced the coaching model in educational settings in the 1980s. However the hiring of mathematics specialists grew in the years that followed the No Child Left Behind (NCLB) Act of 2001 and the accountability movement that followed NCLB, especially in reading and mathematics (Campbell, 2012; Deussen, Coskie, Robinson, & Autio, 2007; Dole, 2004; Johnson et al., 2007). In fact, several states invested heavily in programs that identified, hired, and trained academic coaches as a way to improve students' scores. For instance, the Virginia Board of Education, with the support of the governor, approved a Mathematics Specialist endorsement (Haver, 2008). Virginia school systems employ specialists to work with mathematics teachers in an effort to improve instruction. Other states have invested in specialists for other subjects as well. In 2003 South Carolina made substantial financial investment in science and mathematics coaching initiatives (Dempsey, 2007). In 2012 Tennessee implemented The Tennessee Academic Specialists (TAS) in an effort to support schools that work hard to achieve good standing in AYP (Annual Yearly

Progress) status (Tennessee Department of Education, 2012). The literature makes it clear that school systems place coaches or specialists in schools with the intent of enhancing teachers' instructional practices and improving the chances of student learning, therefore, achieving higher test scores (Bess, 2007; Campbell & Malkus, 2009; Neufeld & Roper, 2003; Obara, 2010). However, according to the research literature, mathematics academic coaches or specialists perform several other functions within a school system.

Coaching Functions or Models

There is no definite model for coaches or specialists; these teacher-leaders serve many functions within the schools (Campbell & Malkus, 2011; Murray et al., 2009). The literature (Becker, 2001; Campbell & Malkus, 2011; Desimone, 2009; Killion & Harrison, 2005; Kohler et al., 1997; Loucks-Horsley et al., 1987; Morgan, 2010; Neufeld & Roper, 2003 ; Walpole & Blamey, 2008) lists several functions that coaches or specialists perform. These functions include, but are not limited to, serving as agents of change to the culture of teacher isolation, implementing professional development that addresses mathematical content, pedagogy, curriculum design, and assessment, leading teacher study groups, observing teachers, coteaching, modeling instruction, debriefing, working with parents and community to promote mathematical learning, assisting administrators and teachers in making sense of student data, understanding research-based best practices for mathematics teaching, providing leadership and vision for school and district-wide mathematics program, and providing leadership for principals and teachers.

A number of educators believe that peer coaching reduces teacher burn-out, stimulates communication, boosts teacher morale, promotes dialogue among teachers, and increases trust and collegiality among teachers (Anastos & Ancowitz, 1987; Chrisco, 1989). Salkind (2010) reported that coaches themselves neither have a clear picture of their functions nor do they engage in a single responsibility. In fact, they engage in multiple roles. The most common roles for 125 elementary school coaches that she studied in five school systems in Virginia included classroom supporters, resource providers, instructional specialists, and data analyzers (Salkind, 2010, p. 165).

In a report prepared for the Institute of Education Sciences (IES) that analyzed the use of coaches in the Reading First, a federal project that aims to improve reading outcomes for students in low-performing K–3 school, Deussen et al. (2007) identified five types of coaches:

- Data-oriented coaches who describe the focus of their work as facilitating the connection between data and instruction.
- Student-oriented coaches who spend more time than other coaches working directly with students and see students as central to what they do.
- Managerial coaches who spend a substantial portion of their time keeping the systems running in their schools—facilitating meetings and keeping up with paperwork.
- Teacher-oriented coaches who work with individual teachers. They spend comparatively little time on paperwork and data-related tasks; they provide of professional development for teachers.
- Teacher-oriented coaches who work with a group of teachers (p. 4).

Neufeld and Roper (2003), documented the functions of what they call "content coaches," coaches who focus on discipline-based instructional improvement. According to them content coaches:

- Help teachers transfer what they learn about new practices to their classrooms.
- Help establish a safe environment in which teachers can strive to improve their practice without fear of negative criticism or evaluation by:
    - working with teachers to plan and implement lessons;
    - working with some content-area teachers to hone specific strategies;
    - developing/finding materials and other curriculum resources;
    - working with new teachers on new-teacher issues as well as on instructional strategies;
    - encouraging teachers to talk about their practice with them and with one another;
    - observing classes and provide written and oral feedback after observations; and
    - providing demonstration lessons.
- Help teachers develop leadership skills with which they can support the work of their colleagues.
- Provide small-group professional development sessions for teachers. (pp. 7-10)

In a study conducted with 15 numeracy coaches in rural Victoria, Australia, Anstey and Clarke (2010) recommended that coaches need the following competencies in order to lead and support change in mathematics education:

- developed capabilities in relation to both content and pedagogical content knowledge of mathematics;
- developed understanding of ongoing formative assessment for leading instructional change, including informed decisions about what data to examine.
- learn to display data meaningfully to help teachers make instructional decisions; and
- use content specific evidence of student learning to lead instructional change(s) at the classroom, team, school, and network level. (p. 29)

From this point forward this literature review presents findings of research that investigates the changes that take place in mathematics teaching due the various coaching experiences and finding of studies that address advancement of students' learning experiences or describe the impact of peer coaching on the improvement of students' scores on high-stakes tests.

Coaches as Agents of Change

Teaching is a moral profession (Fullan, 1993). Most teaching candidates enter the teaching profession with the aim to make a difference in students' lives and society (Steigelbauer, 1992). However, once in the classroom, most teachers fall into a routine and feel isolated from other teachers and from opportunities to grow as professionals (Breyfogle & Spotts, 2011; Neufeld & Roper, 2003). The reason that coaches are put in place is to produce change (Anstey & Clarke, 2010). In order to bring about change, which is part of the moral purpose of teaching, coaches assist teachers in creating a personal vision, developing the desire to seek continuous professional growth, increasing personal mastery and know-how, and creating a culture of collaboration with other teachers (Fullan, 1993). These ingredients, according to Fullan, must be present for effective change.

Keller (2007) reported on three school systems, Adams 12 in Denver, Colorado, Dallas School System, Texas, and Memphis City Schools, Tennessee, that invested in the coaching model and saw positive changes take place. One principal in the Adams 12 system stated that coaching has served to change teachers' attitudes. He remarked that "teachers now believe that they can get kids, no matter what, to achieve in math… they are being more thoughtful about what and how they are teaching" (p. 24).

Bruce and Ross (2008) conducted a qualitative study that had one of its goals to examine the effects of peer coaching on mathematics teaching practices. The study included 12 grade 3 and grade 6 teachers who participated in an intensive 6 months professional development effort focused on successful mathematics teaching strategies and peer coaching opportunities. Credibility of the study was enhanced by using multiple data collection techniques such as classroom observations, teacher self-reflection, interviews, field notes, and the use of multiple interpreters to code the observations (Bruce & Ross, 2008). They reported change in teachers' instructional practices as the main finding of the study. Trained observers rated teachers higher on the rubric for standard-based teaching after they had participated in the study. Teachers moved their practices toward a more student-centered teaching, used more hands-on approaches, created more open-ended tasks, and encouraged students to look for multiples ways to find solutions to problems. Teachers claimed that "the peer coaching process awakened a desire to change" (p. 359).

Coaching and Teachers' Instructional Practices and Beliefs

In addition to mathematical content knowledge, essential for effective teaching, mathematics teachers need to know how children learn and master ways to present content so that students can understand and apply mathematical concepts (NCTM, 1991). Coaches can support teachers' pedagogical growth by instructing them how to effectively use manipulatives, organize students in groups, use technology properly, and by modeling lessons (Obara, 2010). Coaches can also assist teachers in managing students' behavior, engage students in mathematics instruction, and provide differentiated instruction for students with disability or those who have languages deficiencies (Obara, 2010). Several researchers have come to the conclusion that change in teachers' instructional practices, strategies, and techniques is one of the most direct outcome of peer coaching (Bruce & Ross, 2008; Murray et al., 2009; Nickerson, 2009).

In a case-study of an elementary mathematics teacher working with a mathematics coach in a school in New York City, Neuberger (2011) described how the coaching model led to noticeable changes in the teacher's beliefs and pedagogical practices. The experiment occurred in an atmosphere that viewed coaching in a positive light. The principal, the other faculty, and the teacher herself openly and gladly worked with a very skilled coach. Because of the coaching experiment, the teacher grew more confident in her mathematical abilities, demonstrated more reflection about her teaching practices, designed lessons that incorporated more student collaboration, encouraged more divergent thinking from students, approached mathematics teaching as a learning process rather than a right or wrong answer, and paid closer attention to student work in order to guide them in their learning. The peer coaching experience changed the teacher's beliefs and these beliefs led to changes in her actions. Due to the changes that occurred in the teacher's behavior, she spent more class time teaching mathematics. Although the case study reported by Neuberger contained few observations and interviews with the mathematics coach, teacher, and school principal, it does serve to show the potential for teacher pedagogical growth that emerges from the coaching model.

The Bruce and Ross (2008) study found that as a result of peer coaching experience four pairs of grade 3 and two pairs of grade 6 elementary school mathematics teachers changed their teaching toward standard-based practice, increased their confidence in their mathematical abilities, increased awareness of their own teaching practices, and fostered student-to-student communication. The increase in the teachers' self-confidence was derived from successful experiences in teaching mathematical lessons (mastery experiences), the observation of other mathematics successful teaching (vicarious experiences), positive feedback from colleagues, and teachers' feelings about their teaching and learning environments. These findings are congruent with Bandura's self-efficacy theory (1997). Other studies in this literature review reported the positive effect of peer coaching on student interaction (e.g., Kohler et al., 1997; Neuberger, 2011).

Murray et al. (2009) noted teachers' positive perception of a peer coaching activity. They reported the results of a quantitative-qualitative investigation that included 14 teachers in six schools (one K-8 school, three middle schools, and two high schools) from four school districts. These teachers participated in peer coaching in the context of a Mentor Intervention Program (MIP) designed to examine the effects of peer coaching on student achievement in mathematics using quantitative methods and mathematics teachers' collaboration with one another using qualitative methods. In the study teachers participated in 1 to 2 weeks summer institute where they learned standard-based, inquiry-oriented mathematical activities. They coached each other in pairs in the implementation of these activities at the schools they taught. In an open-ended survey teachers specifically mentioned that sharing teaching strategies with peers, receiving feedback from a peer about their teaching, and observing a peer in the classroom helped improve their practices (Murray et al., 2009). Teachers also listed observing one another in the classroom, communicating, and supporting one another as positive outcomes of the Mentored Implementation Program. Although peer coaching did not show statistical significance in the student's mathematics achievements, it did show positive contribution to teacher beliefs and practices.

Kohler et al. (1997) reported on the results of a study involving four elementary schools teachers who used an Integrated Instructional Approach (IIA) to implement direct instruction to their classes. There were three phases to the research. During the baseline phase of the study, which lasted from 5 -10 sessions, teachers planned and implemented the approach independently. Teachers then entered into a peer coaching phase in which they implemented the approach with a peer coach. This phase lasted seven sessions. Lastly, the teachers entered into a maintenance phase in which they worked alone again, and this phase lasted from 5 -10 sessions. Results showed that all four teachers implemented procedural changes in nine areas during the peer coaching phase. These changes remained present in the maintenance phase of the study. For instance, teacher 1 used only one type of activity in lesson closure during baseline (ask students if they liked the activity). During the peer coaching phase she used different activities (gave feedback to students, student discussed activity used, summarized academic content, or gave quiz). The study showed peer coaching as an effective way to implement procedural changes in teachers' instructional practices and these changes can be sustained even after the coaching is discontinued.

In a study designed to examine the effect of reciprocal peer coaching with three kindergarten teachers, Kohler et al. (1999) reported noticeable changes in the way that teachers conducted student pair activities. The study had a multiple baseline design in which teachers implemented the innovation alone during the first stage, then they participated in two coaching stages, and finally they worked alone again. As a result of reciprocal peer coaching the teachers "increased their level of suggestions, prompts, questions, and related talk to increase students' social interactions with peers…. and employed adaptations in the academic materials, skills, or social interaction roles/processes of individual student pairs" (p. 164). The authors recommend peer coaching a viable option to assist teachers in addressing the needs of an ever-changing and diverse student population. Peer coaching led to teachers adapting their instructional practices, a necessary skill to promote the success of students with special needs (Fahsl, 2007; Maccini, Strickland, Gagnon, & Malmgren, 2008).

Kretlow, Wood, and Cooke (2011) described a study designed in a similar fashion to Kohler et al.'s (1997). The study comprised three phases: a baseline, in which teachers implemented direct instruction alone, a post-in-service, and a postcoaching. Three kindergarten teachers taught at a Title I elementary school in the southeastern region of the United States in which 79% of the student population came from low-SES and 46% qualified as English language learners (ELL). The study examined the effects of in-service support plus coaching on teachers' accurate delivery of group instructional units in math to at-risk students. Results indicate that teachers improved their instructional delivery after initial in-service and achieved more growth in the second phase of the study after the introduction of the coaching model (Kretlow et al., 2011).

Coaches used preconferencing, observing, modeling, and debriefing as techniques to assist teachers accurately deliver direct instruction to their students. Teacher 1 improved accurate delivery of instruction from a mean of 37.1% in the baseline stage to 57.3% after the in-service training, to 79.4% after coaching. Teacher 2 improved from a mean of 21% during baseline, to 63.8% after in-service training, to 92.6% after coaching. Similarly teacher 3 improved from a mean of 27.6% correct group instructional units during baseline to 73.7% after in-service training to 91.7% after coaching took place (Kretlow et al., 2011). The three teachers testified to their satisfaction with the coaching experience.

Becker (2001) described the findings of a qualitative study that investigated the usefulness of a coaching project in improving instruction in elementary mathematics classrooms. The study involved 12 teachers and six coaches, although only three specific cases are presented in the study. Coaches in the project had extensive training both in summer institutes as well as follow-up sessions with expert mathematical educators. Becker reported her observations of three coaching styles: collaborative, modeling, and directive. All coaches conducted preconferences, collaborated, modeled, or directed during teacher instruction and held a debriefing conference with the teachers with whom they worked. Independent of the coaching style, it had a positive effect on the teachers. As a result of the peer coaching experience, teachers changed their instructional practices. They felt more comfortable in their teaching of mathematics, they acquired a better understanding of the curriculum, they showed more concern with students' understanding of mathematical concepts, and they "seemed to focus more on the big ideas of mathematics rather than just following the textbook from page to page" (p. 758).

McGatha (2008) documented two cases studies of a teacher-coach undertaking in which three support functions of a mathematics coach based were applied: consulting, collaborating, and coaching. The case studies had as goals to help coaches enhance their coaching skills and to assist teachers in improving their instructional practices. The data consisted of reflective journals, conferences, video-taped meetings, and copies of student work. Data analysis demonstrated coaching as the most promising of the three functions in helping teachers change their practices and become more reflective practitioners. One of the teachers commented on the benefits of the coaching experience. She stated that the benefits to her practice far surpassed those from any other professional development experience in which she had participated.

Walpole, McKenna, Uribe-Zarain, and Lamitina (2010) studied coaching behaviors that effectively promoted change in teachers' practices. The study encompassed 123 coaches and 2,108 K-3 teachers in 113 schools implementing Reading First Georgia. Reading First is a federally funded project that targets low-performing high-poverty elementary schools (p. 120). Using a structured equation modeling they listed three coaching factors that influenced teacher practice: (a) collaboration, (b) coaching for differentiation, and (c) leadership support for coaching. Teachers changed their practices by presenting more effective instruction, managing individual and group work to maximize time on task, designing and using results of formative assessment to guide instruction, and using interactive read-alouds to promote phonological awareness, word recognition, oral reading fluency, vocabulary, and comprehension.

Although many studies have concluded that peer coaching serves as a change agent in teacher's pedagogical practices, other studies have arrived at a different conclusion. In a study about teachers' perceptions of instructional coaching, Horne (2011) found that 536 teachers in three school systems in Northeast Tennessee had either a neutral view of a negative perception that instructional peer coaching improves teacher practices. Horne's finding showed consistency among teachers whose experienced varied between 1- 5 years of teaching, 6 or more years of experience, elementary school teachers, middle school teachers, and high school teachers. From his online survey Horne found that teachers had a neutral or negative perception that peer coaching improves teaching practices. Horne's findings showing a lack of support for peer coaching among this cadre of teacher could be explained by the low level of significance chosen for the study (α=.001). This low level of significance stemmed from a high number of null hypotheses.

In a qualitative study involving three coaches and 11 teachers Morgan (2010) reported the effects of job-embedded professional development delivered by academic coaches on teacher pedagogical practices. To increase internal validity Morgan interviewed and observed participants and analyzed participants' reflective journals. Morgan purposefully selected coaches for the study. The teacher participants represented kindergarten through fifth grade in a Northeast Tennessee school district. All teachers and coaches served in Title I schools. The participants' teaching experience ranged from 1 to 30 years. Six of the teachers held master's degrees, one held an education specialist degree, and two were National Board Certified.

In Morgan's 2010 study teachers and coaches worked together planning lessons, modeling lessons, providing feedback, and using data to make instructional decisions. Morgan listed the following factors that positively influenced coaches in affecting teacher practices:

- teachers being active participants in the coaching process and in their own professional development;
- teachers willing to disclose their area of need;
- teachers and coaches being reflective;
- principals viewing coaches as valuable members of the faculty; and
- coaches' demonstrating actions and possessing traits of an effective coach. (p. 91)

Morgan (2010) identified: “teachers unwilling to see beyond their own practices, teachers not investing in the process, principals' lack of understanding of how to work with or make use of the coach, coaches "wearing too many hats" to be effective, coaches working in more than one school, and coaches and teachers lacking time to work together” (pp. 139-140) as factors that negatively affected coaches’ influence on teacher practices.

Olson and Barrett (2004) reported on a qualitative case study involving three elementary school teachers in a Midwestern school system with a large minority population and high incidence of low scores on mathematics achievement tests. The system had undertaken a change initiative called Primary Mathematics Education Project (PRIME). The initiative had as one of its key features to affect teachers’ practices in three areas: (a) posing worthwhile mathematical tasks, (b) improving questioning techniques, and (c) promoting mathematical thinking by listening and responding to students’ responses. Teachers in PRIME received training in three summer sessions, 4 half-day seminars during the school year, monthly meetings with coaches, and meeting with project staff.

The case study did not confirm the expected results. Olson and Barrett (2004) found that the strategies of PRIME did not encourage the three teachers to change their practices. The three teachers used the innovative materials in traditional ways. They did not encourage student discourse and presented mathematics as only right or wrong answers. The authors posited that perhaps the teachers’ limited understanding of mathematics could have been an impediment to implementing the innovative ideas.

Coaching and Student Outcomes

Dissatisfied with the outcomes of attending conferences, lectures, workshops, and other traditional professional development efforts, school districts across the United States have focused on the appointment of coaches or specialists as a way to raise students' test scores on the mandated state and federal high-stake tests (Obara, 2010; Russo, 2004). Although at the present there is little experimental data to support the claims that the use of academic coaches improves students' test scores, research has demonstrated that coaching affects teachers' perceptions of students' learning and their own instructional capacity (Murray et al., 2009; Neufeld & Roper, 2003).

Coaches use coplanning, coteaching, demonstration, teaching model lessons, observing, postconferencing, and mentoring as strategies to support teachers in acquiring new skills and renewing their mathematical content knowledge that will influence student achievement (Campbell & Malkus, 2011). Campbell and Malkus described the results of a 3-year randomized control-treatment study designed to investigate whether placing mathematics coaches in elementary schools affected student achievement in grades 3, 4, and 5 in five school districts in Virginia. Thirty-six schools representing urban and urban-edge/rural-fringe communities participated in the study. Twelve of them served as treatment sites for the first year. Of the remaining 24 schools, 12 joined the treatment group during the second year. Thus coaches were assigned to the schools in a staggered manner. The coaches involved in the study completed five mathematics courses and one leadership-coaching course prior to their assignment. They took a second leadership-coaching course during their first year on the job. The study controlled for teacher experience, prior school academic tradition in mathematics, school size, and student demographics. Student achievement data were measured by the high-stakes Standards of

Learning (SOL) assessment administered in Virginia in grades 3–5 (p. 434). The study involved 24,759 students in the treatment and control groups.

Campbell and Malkus (2011) stated that over time students enrolled in treatment schools achieved significant higher than students in the control groups. Although there were several limitations to the study reported by Campbell and Malkus, including the "lack of data of addressing the teachers' mathematical content knowledge growth during the study, pedagogical content knowledge, knowledge of mathematics for teaching, or beliefs about mathematics teaching and learning" (p. 451), it is possible to consider the potential for coaches' impact on student achievement, especially if these coaches are given the time to build trusting relationships with teachers and administrators. These findings are consistent with Desimone's (2009) conclusions that to be effective professional development needs to be sustained over time and highly collaborative. Campbell and Malkus (2011) addressed the lack of evidence that student achievement increased during the first year of coach placement, but data showed the increased achievement during the second year of coach placement.

In a testimony before the Committee on Education and Labor in the United States House of Representatives, on May 18, 2008, William Haver (2008) of The Virginia Commonwealth University affirmed that the Virginia mathematics coalition had identified the use of a mathematics specialist as the most promising means to improve student achievement in grades K-12. Haver also testified that initial results from SOL tests in Virginia had shown that students in schools that employ mathematics specialists have performed better than students in control groups for grades 3, 4, and 5. Haver's data originated from the same source as the Campbell and Malkus (2011) study.

Foster and Noyce (2004) reported the results of a Mathematics Assessment Collaborative (MAC), funded by the Noyce Foundation and the school districts involved in it, in 30 school districts in California's Silicon Valley in which coaching was introduced. In this effort coaches received 1-week long training in August, prior to the beginning of the school year, in mathematics content, pedagogy, leadership skills, and coaching techniques (Foster & Noyce, 2004). During the school year coaches spent 70% of their time coaching peers in the classrooms. The results indicate that students whose teachers participated in the coaching program outperformed their peers on the California state test, STAR (Standardized Testing and Reporting). More importantly, students whose teachers participated in the coaching effort improved their understanding of mathematical concepts as tested by the more rigorous performance assessment administered by the MAC. Students' understanding seemed to evolve as students progressed from year to year (Foster & Noyce, 2004). Although this study showed the promises of the coaching model, one must be aware that its findings were based on a posttest-only intact-group design, there was no randomized control group, and it did not account for possible initial differences between participating schools.

Vale et al. (2010) described a project designed to improve the mathematics outcomes for students in low socioeconomic status (SES) schools and networks of schools. The study involved 43 schools in two networks of schools in rural Victoria, Australia. These communities were considered the poorest school communities in rural Victoria. The school leadership employed numeracy (mathematics) coaching as a way to change teachers' practices. One of the principals observed the successes listed below as results of coaching initiative:

- Greater use of data in lesson planning, differentiating and reviewing;

- Increased level of conversation about student learning in literacy and numeracy (mathematics);
- Younger teachers more prepared to engage in and lead the improvement agenda;
- Greater confidence and skills in coordinators;
- Teachers moving from compliance to more active engagement;
- Coaches relentless, resilient and hard working and provide high level of expertise; and
- Collaborative neighborhood networking is building lateral capacity and collegiality. (p. 67)

The changes that occurred in teachers' practices showed some positive results. Among these results, data showed that growth number achievement for primary and secondary student who belong to the lowest SES reached expected or greater than expected growth in a 6-month period (Vale et al., 2010).

Nickerson (2009) documented the outcomes of an effort undertaken by a local university and a large urban school system to address the low performance in mathematics of students in eight schools that she called Focused Schools. There were 32 teachers who engaged in a program that trained them in mathematics content and pedagogy and offered them on-site support through the use of mathematics coaches.

Between 92% - 100% of the students in the Focused Schools lived below poverty level and, in some schools, as many as 91% qualified as limited English proficiency. At the beginning of the study, 42% of the students performed in bottom quartile of the national distribution on the Stanford Achievement Test Ninth Edition (SAT-9) compared to 20% of the other students in elementary schools in the district (Nickerson, 2009).

At the end of 3 years researchers measured student outcomes using performance assessment tasks, teacher's perceptions of student learning, and results from state-mandated achievement tests.   Performance assessments revealed a growth in students' understanding of mathematical processes over time. Teachers reported higher student interest in mathematics and longer persistence by students in solving mathematical problems. SAT-9 gains of 2,844 students from the Focused Schools exceeded gains from students in schools in the same district, county, and state (Nickerson, 2009). These findings showed promise of coaching in bridging the achievement gap of students in low SES schools.

Dobbins (2010) reported the results of a study to evaluate the relationship between the coaching model and the mathematics achievement of students in grades 5 through 8 at a charter middle school in the southern United States. The results of a dependent samples *t* test on district quarterly mathematics data from the Northwest Education Association Measure of Academic Progress (NWEA MAP) showed a statistically significant increase in mathematics achievement from third to fourth quarter for 400 students in grades 5 through 8, $t(399) = -4.011$, $p = 0.028$ (p.117). Although the study had limited timeframe (it only analyzed data between third and fourth quarters), it supported the feeling that many researchers have about the potential that coaching has to positively influence student learning and achievement (Desimone 2011; Jeanpierre et al., 2005; Johnson et al., 2007; Penuel et al., 2007).

Reed-Wright (2009) conducted a study to evaluate the changes that occurred as a result of a job-embedded or coaching initiative at the elementary level in a school system in Northeast Tennessee. One of the research questions stated "Did job-embedded professional development contribute to improved student performance?" (p. 24). Data originated from observations, interviews, and document reviews. The study involved teachers, principals, and literacy coaches.

Data came from 27 sources. In the 5-year span of a coaching initiative, data showed an increase in students' scores in reading and language arts. There was a 6% gain in proficiency for all students. All subgroups (White, African-American, Asians, Hispanics, economically disadvantage, students with disabilities, and Asian/Pacific Islanders) except those of limited English proficiency showed positive gains (Reed-Wright, 2009).

Although a number of researchers have concluded that instructional or peer coaching has the potential to positively influence student outcomes, especially if coaching takes place over an extended period of time (Campbell & Malkus, 2011), data exist that do not support this premise. In the study of teachers' perception of coaching effectiveness Horne (2010), mentioned earlier in this literature review, found that teachers did not perceive that coaching would influence student outcome. One teacher stated that "teachers impact student learning, not coaches" (p. 111).

Coaching and Curriculum

The quality of curriculum that teachers present to students has a significant contribution to students' achievement. According to Kilpatrick (as cited by Obara, 2010) curriculum involves selection of materials, teaching goals, type of instruction, content of instruction, and assessment. Mathematics coaches need to have a sophisticated knowledge of curriculum so they can help in the sequencing of topics to be taught and assist teachers in understanding the connection of mathematical concepts from grade to grade (Obara, 2010). Walpole and Blamey (2008) affirmed that coaches spend part of their time in matters related to curriculum such as ensuring the alignment of curriculum to state and national standards, buying and organizing curricular materials, scheduling instruction, and developing assessment. Coaches and teachers use formative and summative data to evaluate student progress, plan reteaching, and implement instruction that meet student needs (Saphier & West, 2009).

Obara (2010) stated that coaches can acquire in-depth knowledge curriculum by taking graduate courses about curriculum development from universities, inviting curriculum publishers to lead on-site training sessions and workshops, attending summer institutes, and reading current research about curriculum. Harrison and Killion proposed 10 functions for coaches or teacher leaders. Curriculum expert is a part of the list. As curriculum experts, teacher leaders must understand national and state standards, be able to see the connections in curriculum across grades, plan instruction, and design assessment (Harrison & Killion, 2007).

According to West and Staub (2003) coaches assist teachers in addressing curriculum issues by helping them focus on the lesson design. Specifically, coaches can help teachers make decisions that address the following aspects of lesson design:

- What are the goals and overall plans for the lesson?
- What is the mathematics in this lesson? (Make lesson goals specific).
- Where does this lesson fall in the unit and why? (Clarify the relationship between the lesson, the curriculum, and the standards).
- What are the students' prior knowledge and difficulties?
- How does the lesson help students reach the goals? (think through the implementation of the lesson). (pp. 5-9)

Von Rotz (2006) stated that mathematics coaches help teachers understand how the curriculum develops and progresses across grade levels. In his coaching experience he developed a bulletin board where he posted student work from different grade levels. This practice assisted teachers to observe how student mathematical concepts developed over time.

Teachers from different grade levels viewed the bulletin board as sources of information about the mathematical concepts they needed to address at their grade level.

Conclusion

The perceived low quality of mathematics education alarms the international community. Mathematical literacy can no longer belong to just a few citizens. Responsible citizenship depends on a mathematically literate population. Schools of education have an enormous responsibility to educate those who will become instructors of mathematics to our future generations.

In the United States schools administrators work under pressures from federal and state governments, community leaders, and parents in regard to student outcomes, especially taking into account the demands of high-stake accountability tests that are mandated by NCLB Act of 2001. School leaders need to come to the realization, supported by the research literature, that the experiences teachers present students shape student learning. These leaders need to realize that teacher preparation programs may not produce graduates who can step into the classroom and teach a reformed mathematical curriculum and that the traditional modes of professional development including workshops and 1-day conferences do not promote effective teacher growth. Therefore, school systems across the country need to invest in coaches or specialists that can provide on-site, job-related professional development to their teachers. Although in its infancy, peer coaching has shown some positive effects on teacher beliefs, sense of self-efficacy, and student achievement.

CHAPTER 3

RESEARCH METHODOLOGY

The purpose of this study was to investigate the difference between students' achievement levels before and after a mathematics initiative in a Northeast Tennessee school district. Tennessee Comprehensive Assessment Program (TCAP) scores were used for achievement levels. A mathematics specialist serving as a coach was part of the mathematics improvement initiative. The study specifically focused on students in grades 3 through 6 in 2010 and the same students 2 years later, 2012. In 2012 these students were in grades 5 through 8, respectively. Students were included in this study if there were test scores for both years. This chapter presents the research design, population, data collection methods, and data analysis.

This research is quantitative in nature using an ex post facto methodology. All students in grades 3 through 8 in Tennessee are expected to take a statewide standardized test, Tennessee Comprehensive Assessment Program or TCAP. TCAP is a timed, multiple-choice achievement test. The TCAP Achievement Test is a criterion-referenced test that has original nonrepetitive questions and is modified yearly to measure academic skills and knowledge in reading/language arts, mathematics, science, and social studies. Criterion-referenced tests measure a student's performance against specific content standards. Curriculum standards as defined by the state of Tennessee provide expectations for student accomplishment. From these expectations state performance indicators (SPIs) were developed to describe how the expectations would be measured. On the TCAP Achievement Test, each test item is directly linked to a SPI. TCAP serves to fulfill the expectations for assessment required by NCLB. This study was conducted to investigate the difference between students' achievement levels before and after a mathematics initiative.

I analyzed data from all the third, fourth, fifth, and sixth graders who were continuously enrolled in a Northeast Tennessee School District and took the TCAP assessment during the time of the study. There are 863 participants in the study. The study shows a comparison of students' TCAP scores the year prior to the use of the mathematics specialist, the school year of 2009-2010, and students' respective scores 2 years after the specialist served as their teachers' academic coach, that is, the academic year of 2011-2012. The study also identifies the affect on achievement of students who attend Title I schools. The TCAP assessment is administered in the spring of each year, usually in the third week in April. Table 3 shows the mathematics scores required for below basic, basic, proficient, and advanced status for grades 3 through 6. Scaled scores range from 600 to 900. Scores are also given in five subscale scores addressing mathematical processes, number and operations, algebra, geometry and measurements, and data analysis, statistics, and probability.

Table 3

Tennessee Comprehensive Assessment Program or TCAP Mathematics Scores for 2010 and 2012

Grade	Below Basic	Basic	Proficient	Advanced
3	600-702	703-754	755-790	791-900
4	600-721	722-766	767-798	799-900
5	600-727	728-763	764-794	795-900
6	600-732	733-769	770-794	795-900

Note: Source: Tennessee Department of Education Web site

Research Questions and Null Hypotheses

The following research questions and null hypotheses were used to guide the study:

1. Are there significant differences in student mathematics achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP)?

H_01_1 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative).

H_01_2 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative).

H_01_3 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative).

H_01_4 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative).

H_01_5 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative).

2. Are there significant differences in students' mathematics achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP) with regard to Title I or non-Title I schools?

H_02_1 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to Title I schools.

H_02_2 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to non-Title I schools.

H_02_3 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to Title I schools.

H_02_4 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to non-Title I schools.

H_02_5 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to Title I schools.

H_02_6 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to non-Title I schools.

H_02_7 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative) with regard to a Title I school.

H_02_8 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative) with regard to a Title I school.

Population

The population for this study includes all the third, fourth, fifth, and sixth grade students who were continuously enrolled in a Northeast Tennessee School District and took the TCAP assessment during the school years of 2009-2010 and 2011-2012. There are 863 participants in the study. The study compares students' TCAP scores for the year prior the use of the mathematics specialist and 2 years after the specialist served as their teachers' academic coach. An analysis is carried out on the data that indicates whether or not students attended schools considered Title I to determine whether the use of a mathematics specialists affects student achievement with regard to Title I or non-Title I schools.

Data Collection

I requested and was granted approval for this study from the Institutional Review Board (IRB) at East Tennessee State University and from the Director of Schools of the participating system. TCAP data were then collected from the district's central office. I received a file with students' TCAP score for 2010 and another file with TCAP scores for 2012. From the 2010 file I used TCAP scores for students in grades 3 through 6. From the 2012 file I used the same students' TCAP scores, but at that time they were in grades 5 – 8 respectively. There was no identifiable student information in these file. Each student was identified by a nine-digit student identification number. The files also contained students' grade level and whether or not they attended a school that was classified as Title I school. No information that can identify participants was provided by central office. Participants' anonymity will be preserved.

Data Analysis

The null hypotheses under research question 1 and research question 2 were analyzed with pair-sampled t-tests using repeated-measures design. Research question 1 addresses the overall difference in achievement levels of student in grades 3 through 6 as measure by TCAP scores and the use of a mathematics specialist. The dependent variables are TCAP scores for 2010 and 2012. The independent variables are the grade level of each student and the presence or absence of mathematics coach or specialist.

The second research question addresses the difference in achievement levels based on the fact that the students attended schools designated either as Title I schools or non-Title I and the use of the mathematics specialist. The independent variables are school designation (Title I or non-Title I) and the presence or absence of a mathematics specialist. The dependent variables were the TCAP scores achieved by the students in 2010 and 2012 specified by grade level. All statistical analyses were performed by the Statistical Program for the Social Sciences (SPSS) and performed with a .05 level of significance.

Summary

This chapter presented the methodology and procedures employed to analyze TCAP scores of a population of student in grades 3-6 who attend elementary schools in a Northeast Tennessee school system. Data were analyzed to determine the difference in student achievement levels before and after the use of a mathematics coach or specialist. Data were also analyzed to determine the difference in achievement levels of students who attended Title I or non-Title I schools after the use of a coach or specialist.

CHAPTER 4

FINDINGS

This chapter contains the results of the data analysis related to the research questions listed in Chapters 1 and 3. The purpose of this study was to investigate the difference in students' achievement levels as measured by the Tennessee Comprehensive Assessment Program (TCAP) before and after the use of a mathematics specialist in grades 3 through 6 in a Northeast Tennessee school district. The number of students by grade level is reported in Figure 1. There were 863 cases in all. The data were gathered from TCAP scores of students in grades 3 – 8 collected from the district's central office. I gathered the data from two documents. One document had students' TCAP scores for 2010 and another document had TCAP scores for 2012. There was no identifiable student information in these files. Each student was identified by a nine-digit student identification number. The files also contained students' grade level and whether or not they attended a school that was classified as Title I school.

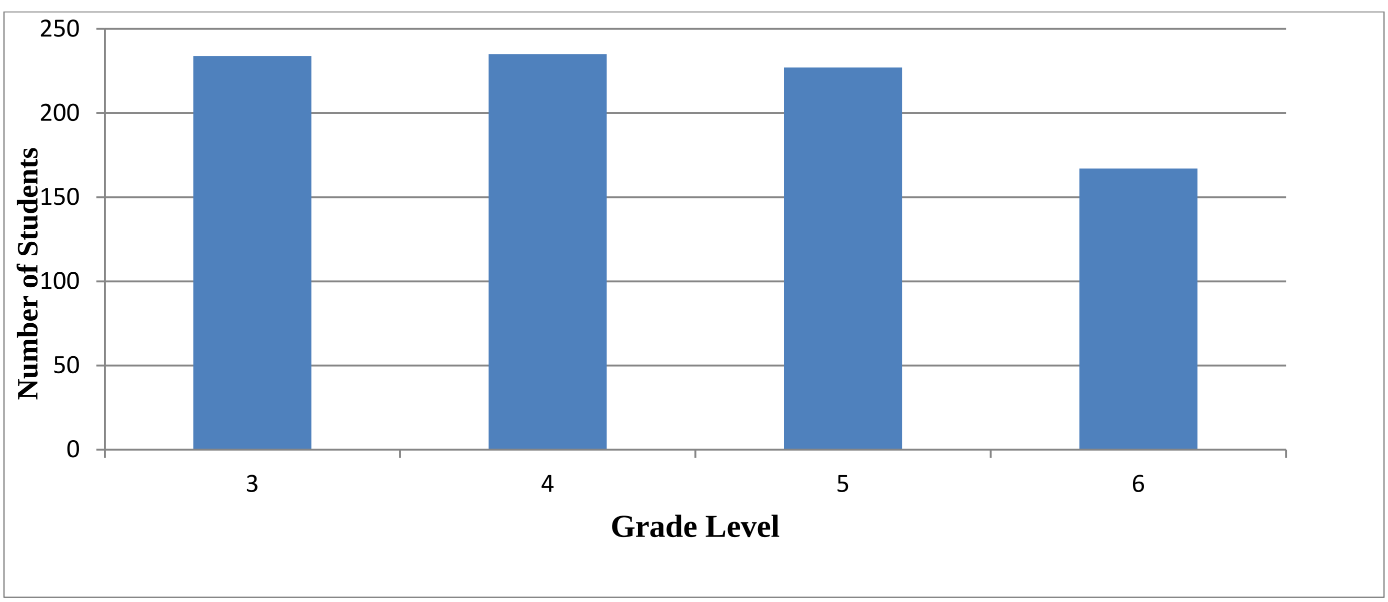

Figure 1. Number of Students by Grade Level in 2010

In 2011 the school district hired a mathematics curriculum coach or specialist as part of its improvement effort to raise student TCAP scores in mathematics. Thus, there was no mathematics coach or specialist present in 2010 and by 2012 the specialist had been working with teachers in the system for 2 years. The mathematics coach was a middle school mathematics teacher who had been teaching in the system for 18 years; 10 years as a fifth grader teacher and 8 years in seventh grade. There was no special training offered to the coach at the time of hiring. The coach was an experienced classroom teacher who had been awarded recognition for her excellent teaching. The coach's training included a master's in K-6 mathematics teaching.

The coach responded to principals' and teachers' request for assistance. The coach assisted teachers with lesson design, organized and presented workshops for teachers, found diverse resources for teachers, and scheduled guest speakers and webinars that addressed mathematical content. The coach also observed teachers, cotaught with them, assisted with the design of benchmark tests and other assessments, and met with teachers to debrief them after coaching sessions. Time was not evenly divided among schools or even teachers. Teachers at Title I schools received more individual assistance than those who taught at non-Title I schools. Two of the five schools elementary schools were Title I schools and the only middle school was a Title I school.

According to the State of Tennessee Department of education, students in grades 3 through 8 in the district had shown no change (NC) in achievement over the period from 2010-2012 in reading/language, social studies, and science. The same group of students had shown positive mathematics achievement in the same time period. Table 4 below shows district achievement trends from 2010 to 2012. [1] Table 5 shows statewide achievement trends for the same time period.[2]

Table 4

Grades 3-8: District TCAP Criterion Referenced Academic Achievement (CRT)

(3 year average)	2010		2011		2012		
CRT	Score	Grade	Score	Grade	Score	Grade	Trend (1)
Math	54	B	54	B	55	A	+
Reading/Language	53	B	53	B	53	B	NC
Social Studies	55	A	57	A	59	A	NC
Science	52	B	52	B	53	B	NC

Note: The data were gathered from Tennessee Department of Education Web site.

Table 5

Grades 3-8: Statewide TCAP Criterion Referenced Academic Achievement (CRT)

(3 year average)	2010		2011		2012		
CRT	Score	Grade	Score	Grade	Score	Grade	Trend (2)
Math	49	C	50	B	52	B	NC
Reading/Language	49	C	49	C	50	B	+
Social Studies	51	B	52	B	54	B	NC
Science	49	C	49	C	50	B	+

Note: The data were gathered from Tennessee Department of Education Web site.

[1] The Department of Education considered only grades in determining the district 3-year trend.

[2] The Department of Education considered only grades in determining the state 3-year trend.

Analysis of Research Questions

Research Question #1

Are there significant differences in student mathematics achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP)?

There are five null hypotheses associated with this research question. Each null hypothesis is listed and analyzed below.

H_01_1 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative).

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement level measured by TCAP scores before improvement initiative and postimprovement initiative. The dependent variables were 2010 and 2012 TCAP scaled scores that can vary from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, $t(862) = 22.79$, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' scores in 2012 (M = 772.94, SD = 36.76) were significantly higher than their scores in 2010 (M = 752.02, SD = 35.27). The 95% confidence interval for the difference in means was 19.12 to 22.72. The η^2 index was .38, which indicated a large effect size. Students' mathematics achievement scores were on average higher after the specialist worked with teachers in the school system. The 95% confidence interval for the difference in means as well as the means and standard deviations for all the students are reported in Table 6. Figure 2 shows the distribution for the two groups.

Table 6

Means and Standard Deviations of All Students and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	863	752.02	35.27	19.12 to 22.72
After Specialist	863	772.94	36.76	

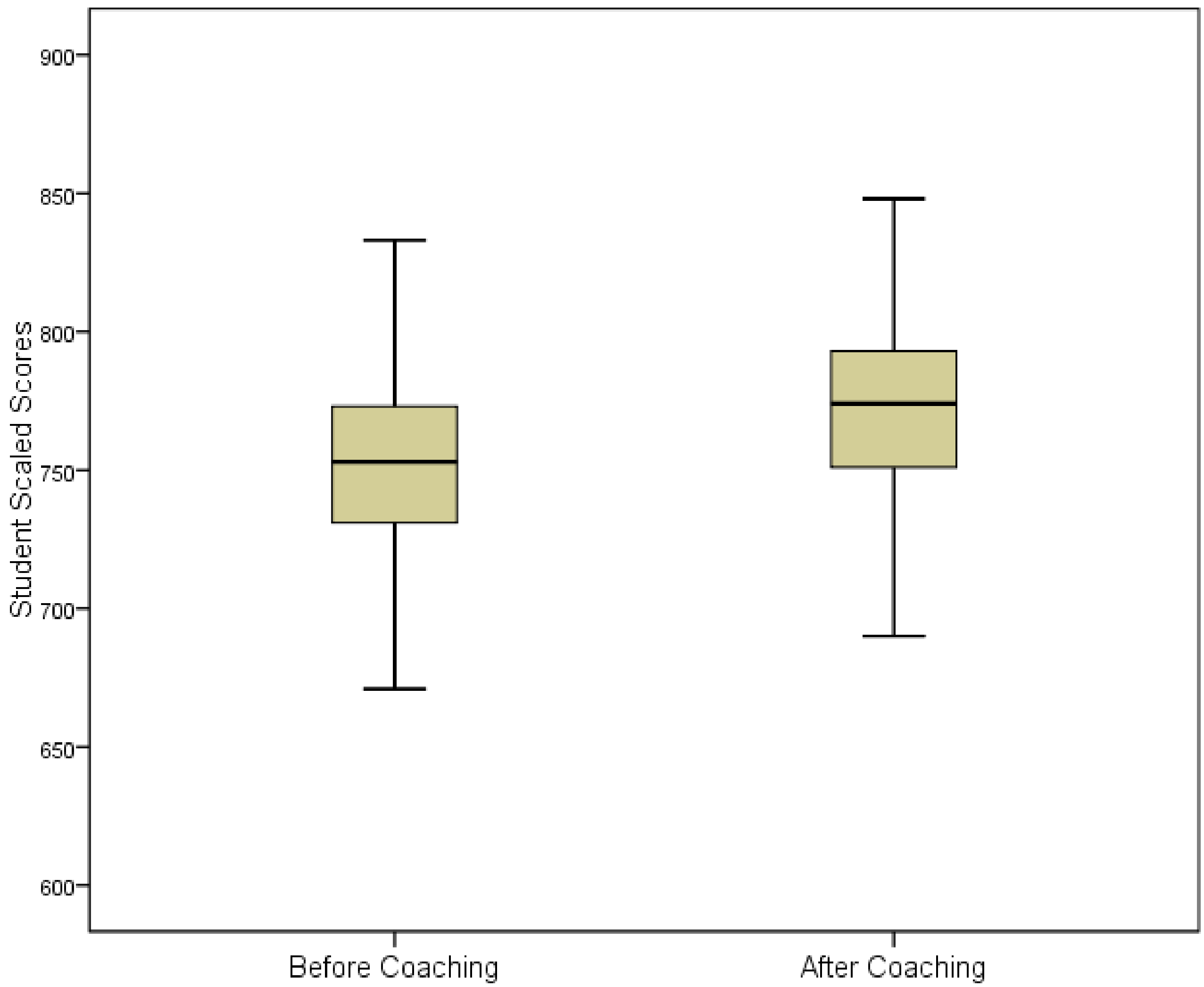

Figure 2. Distribution of Scores for All Students Before Specialist and After Specialist

H_01_2 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative).

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement level measured by TCAP scores before specialist and postspecialist for all third graders. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (233) = 9.88, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' fifth grade scores in 2012 (M = 776.83, SD = 34.63) were significantly higher than their third grade scores in 2010 (M = 758.63, SD = 34.93). The 95% confidence interval for the difference in means was 14.57 to 21.83. The η^2 index was .30, which indicated a large effect size. These students' mathematics achievement scores were on average higher after the specialist worked with teachers in the school system. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 7. Figure 3 shows the distribution for the two groups.

Table 7

Means and Standard Deviations of All 2010 Grade 3 Students and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	234	758.63	34.93	14.57 to 21.83
After Specialist	234	776.83	34.63	

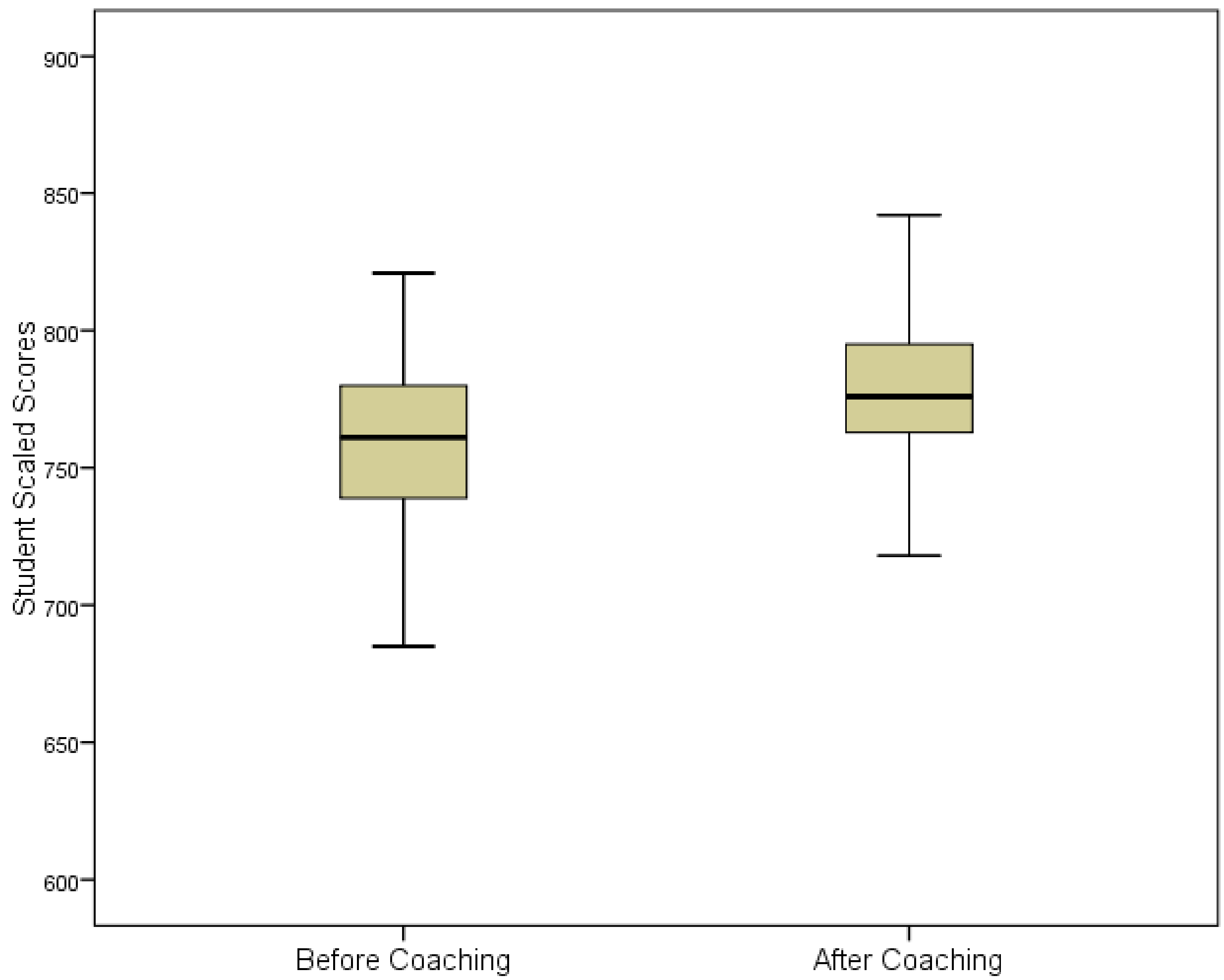

Figure 3. Distribution of Scores for All 2010 Grade 3 Students Before Specialist and After Specialist

H_01_3 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative).

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores before specialist and postspecialist for all fourth graders. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (234) = 13.72, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' sixth grade scores in 2012 (M = 777.29, SD = 41.01) were significantly higher than their fourth grade scores in 2010 (M = 753.09, SD = 32.49). The 95% confidence interval for the difference in means was 20.73 to 27.68. The η^2 index was .45, which indicated a large effect size. These students' mathematics achievement scores were on average higher after the specialist worked with teachers in the school system. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 8. Figure 4 shows the distribution for the two groups.

Table 8

Means and Standard Deviations of All 2010 Grade 4 Students and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	235	753.09	32.49	20.73 to 27.68
After Specialist	235	777.29	41.01	

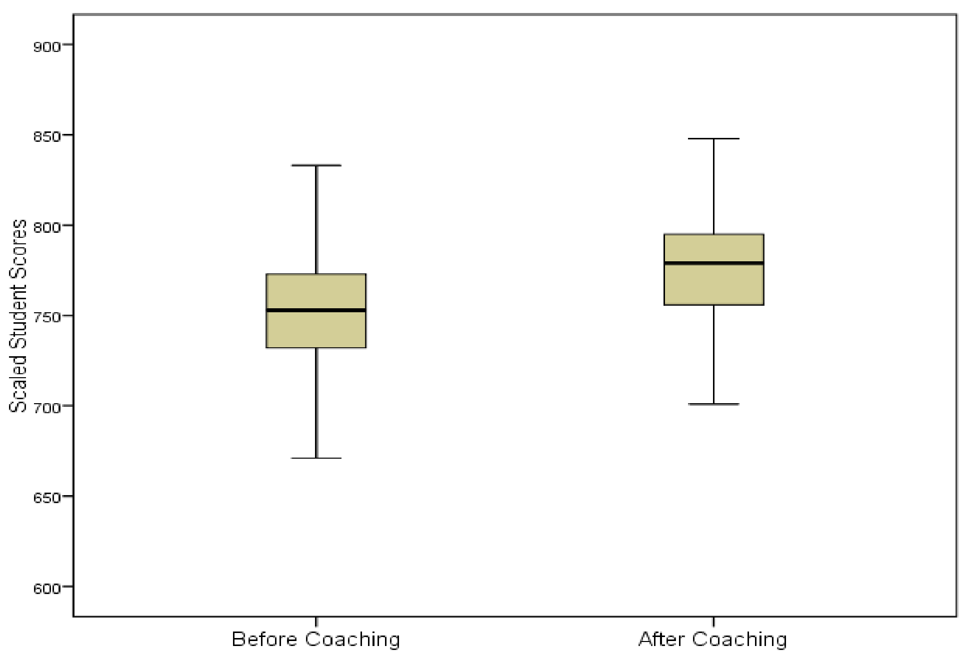

Figure 4. Distribution of Scores for All 2010 Grade 4 Students Before Specialist and After Specialist

H_01_4 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative).

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores before specialist and postspecialist for all fifth graders. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (226) = 15.03, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' seventh grade scores in 2012 (M = 778.97, SD = 34.31) were significantly higher than their fifth grade scores in 2010 (M = 753.15, SD = 38.96). The 95% confidence interval for the difference in means was 22.44 to 29.20. The η^2 index was .50, which indicated a large effect size. These students' mathematics achievement scores were on average higher after the specialist worked with teachers in the school system. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 9. Figure 5 shows the distribution for the two groups.

Table 9

Means and Standard Deviations of All 2010 Grade 5 Students and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	227	753.15	38.96	22.44 to 29.20
After Specialist	227	778.97	34.31	

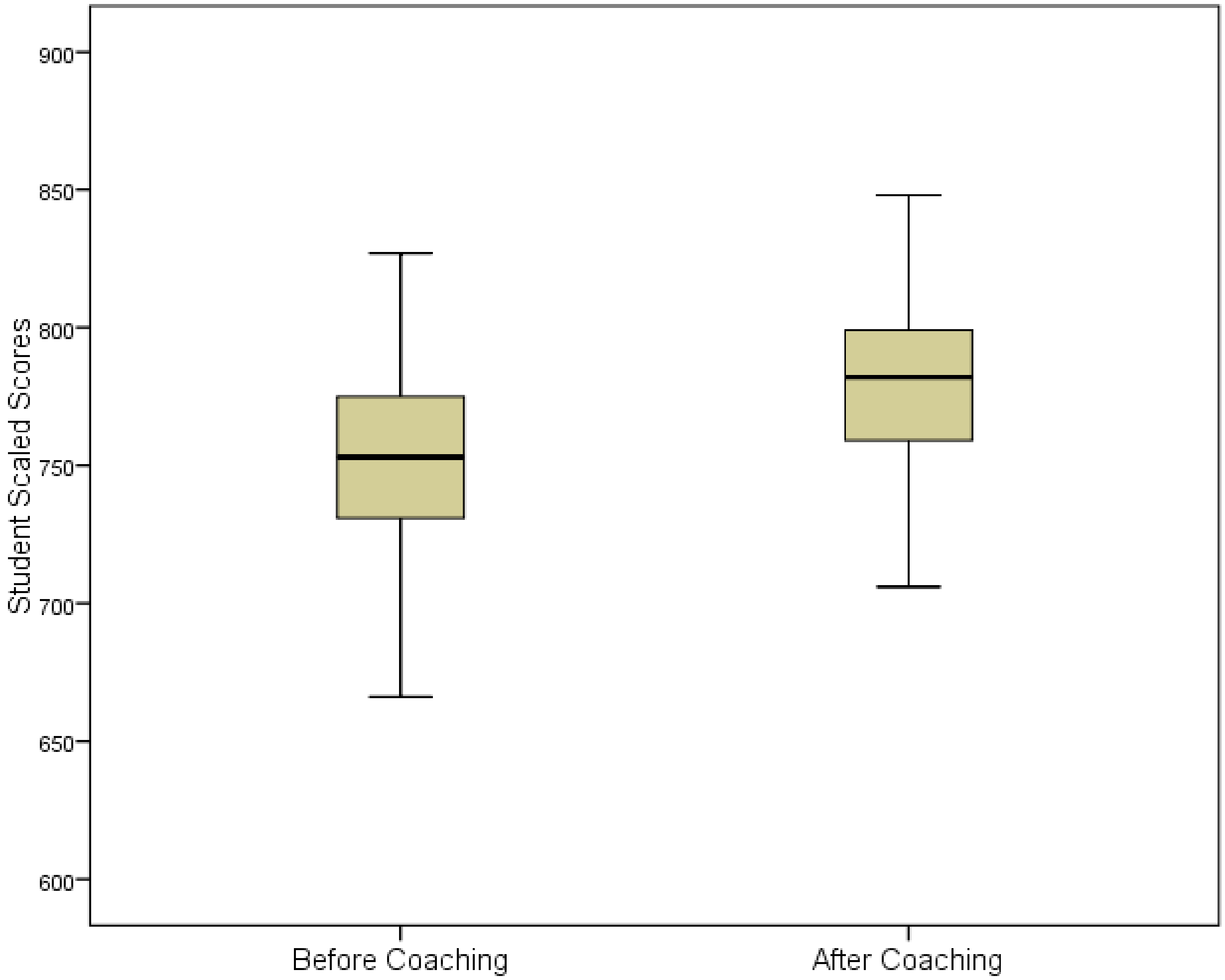

Figure 5. Distribution of Scores for All 2010 Grade 5 Students Before Specialist and After Specialist

H_01_5 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative).

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores before specialist and postspecialist for all sixth graders. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (166) = 7.07, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that eight grade students' scores in 2012 (M = 753.17, SD = 29.53) were significantly higher than their sixth grade scores in 2010 (M = 739.71, SD = 31.25). The 95% confidence interval for the difference in means was 9.70 to 17.22. The η^2 index was .18, which indicated a large effect size. These students' mathematics achievement scores were on average higher after the specialist worked with teachers in the school system. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 10. Figure 6 shows the distribution for the two groups.

Table 10

Means and Standard Deviations of All 2010 Grade 6 Students and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	167	739.71	32.25	9.7 to 17.22
After Specialist	167	753.17	29.53	

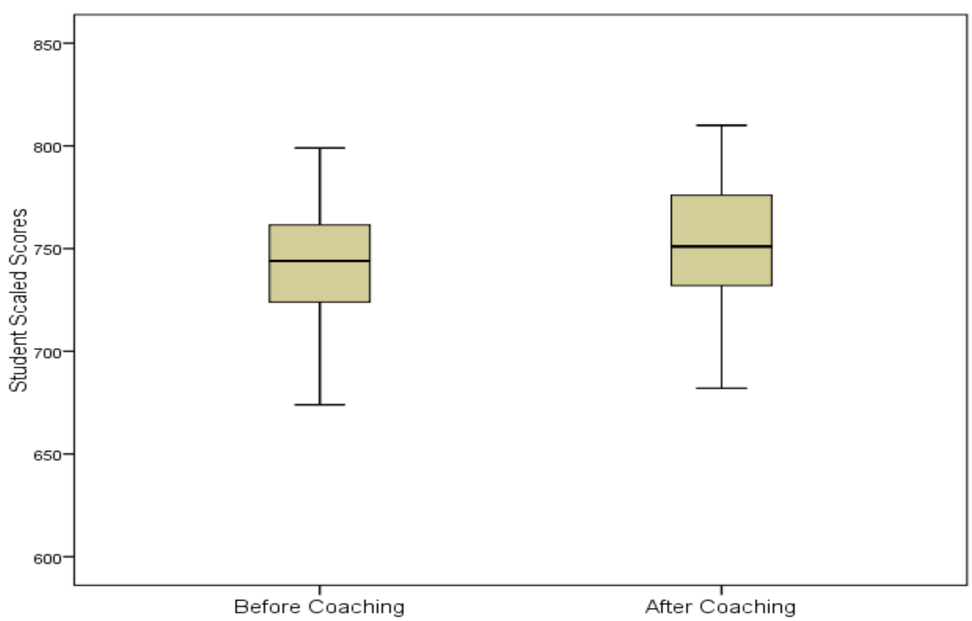

Figure 6. Distribution of Scores for All 2010 Grade 6 Students Before Specialist and After Specialist

Research Question #2

Are there significant differences in students' mathematics achievement before and after the implementation of a mathematics improvement initiative as measured by the Tennessee Comprehensive Assessment Program (TCAP) with regard to Title I or non-Title I schools?

There were eight null hypotheses associated with this research question. Each null hypothesis is listed and analyzed below. There are no null hypotheses concerning fifth and sixth graders who are in non-Title I schools because in 2012 these students attended the only middle school in the district, which is a Title I school.

$H_0 2_1$ There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to a Title I school.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores before specialist and postspecialist for all students who were in schools considered Title I schools during the school year 2011-2012. There were two elementary schools and one middle school. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, $t\ (549) = 17.59$, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' scores in 2012 (M = 767.51, SD = 36.13) were significantly higher than their scores in 2010 (M = 747.11, SD = 35.18). The 95% confidence interval for the difference in means was 18.12 to 22.67. The η^2 index was .36, which indicated a large effect size. Students in Title I schools demonstrated higher mathematics achievement scores were on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for all the students are reported in Table 11. Figure 7 shows the distribution for the two groups.

Table 11

Means and Standard Deviations of All Students Who Attended Title I Schools and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	550	747.11	35.18	18.12 to 22.67
After Specialist	550	767.51	36.13	

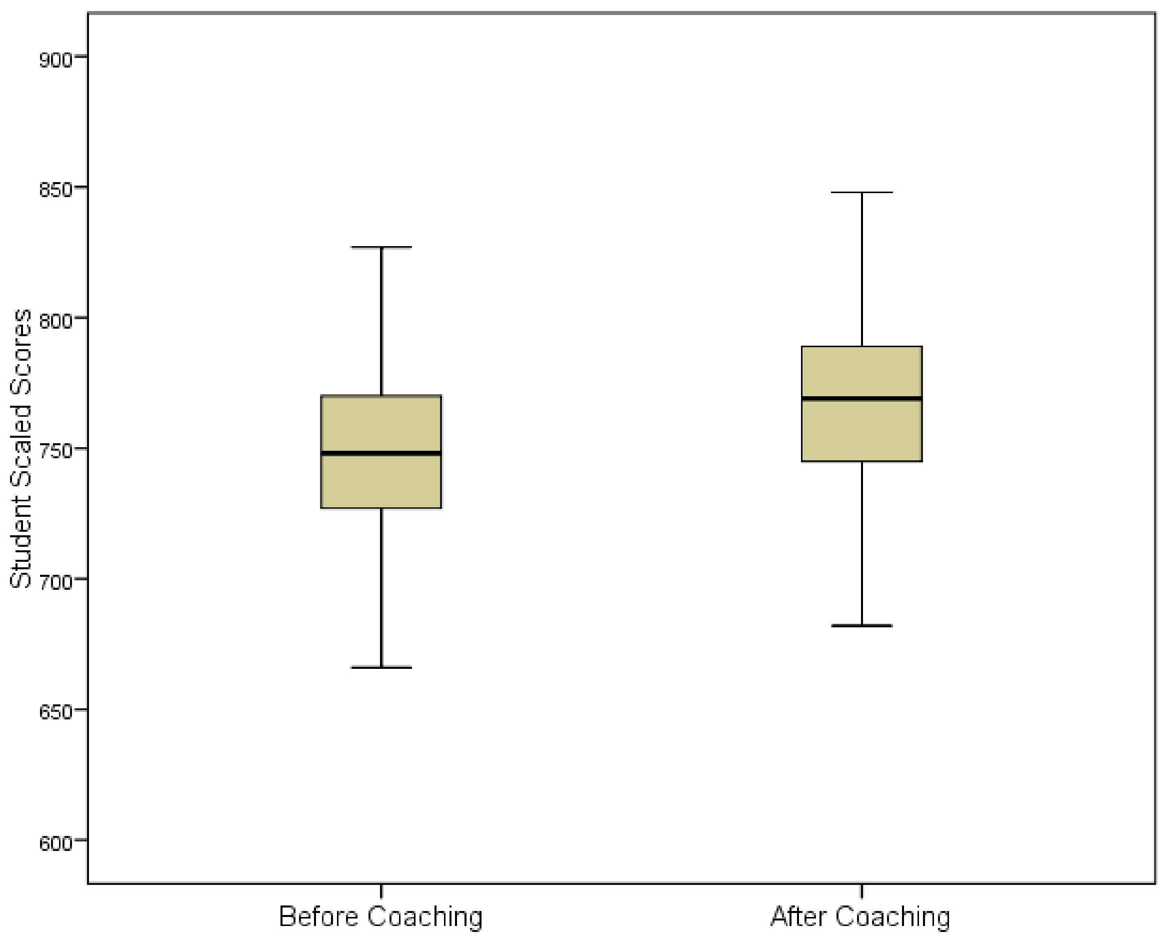

Figure 7. Distribution of Scores for All Title I Students Before Specialist and After Specialist

H_02_2 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to a non-Title I school.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores before specialist and postspecialist for all students who attended non-Title I schools during the school year 2011-2012. There were three elementary schools in this category. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, $t(312) = 14.54$, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that students' scores in 2012 (M = 782.48, SD = 35.96) were significantly higher than their scores in 2010 (M = 760.64, SD = 33.80). The 95% confidence interval for the difference in means was 18.89 to 24.80. The η^2 index was .40, which indicated a large effect size. Students in non-Title I schools demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 12. Figure 8 shows the distribution for the two groups.

Table 12

Means and Standard Deviations of All Students Who Attended non-Title I Schools and the 95% Confidence Interval

Student Group	N	M	SD	Confidence Interval
Before Specialist	313	760.64	33.80	18.89 to 24.80
After Specialist	313	782.48	35.96	

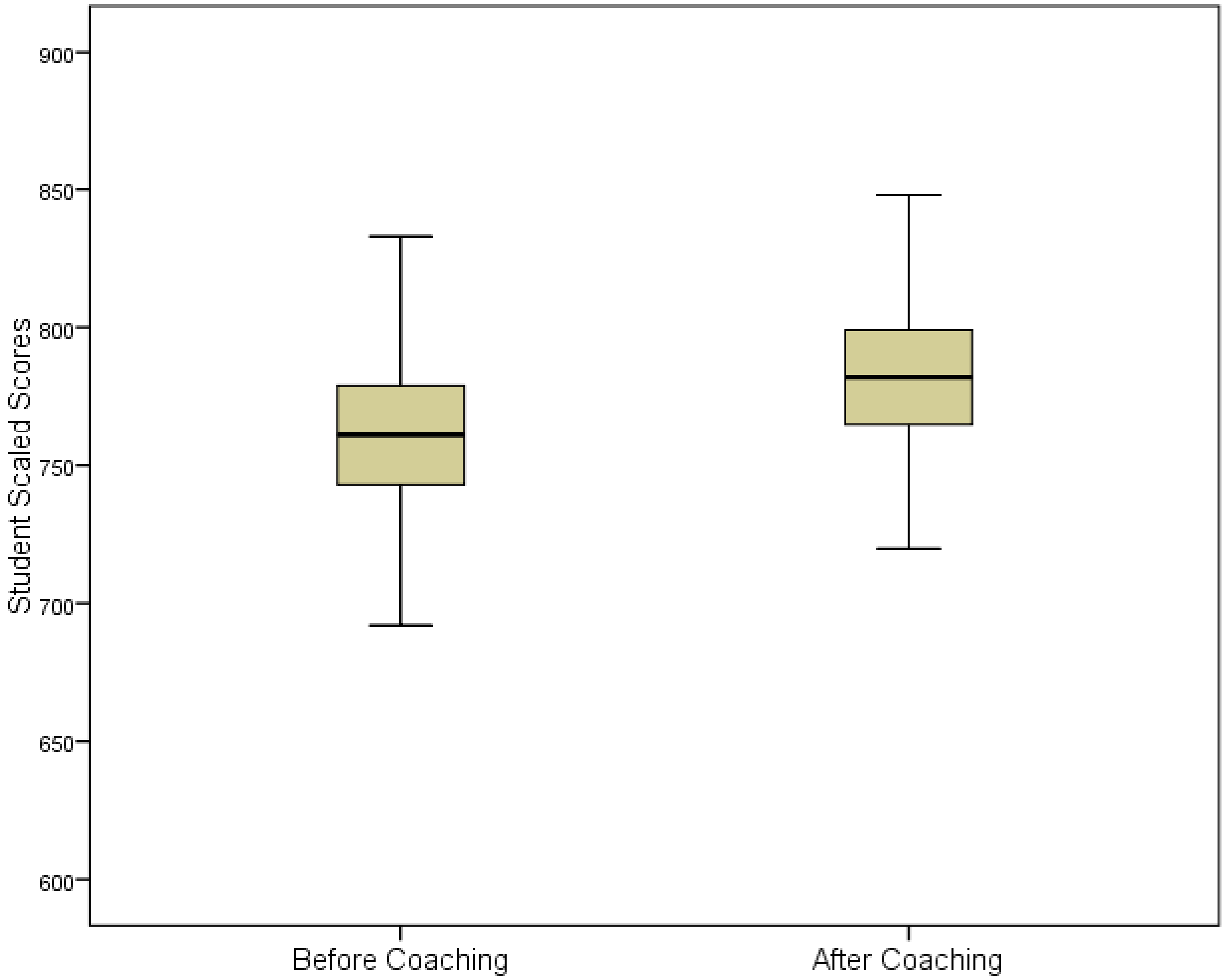

Figure 8. Distribution of Scores for All non-Title I Students Before Specialist and After Specialist

H_02_3 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to Title I schools.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were in Title I schools in third grade in 2010 and in fifth grade in 2012. There were two elementary schools that were considered Title I schools. The dependent variables were 2010 and 2012

TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (72) = 3.92, p < .01. Therefore, the null hypothesis was rejected. The results indicate that fifth grade students' scores in 2012 (M = 759.55, SD = 39.65) were significantly higher than their third grade scores in 2010 (M = 743.86, SD = 32.62) with regard to Title I schools. The 95% confidence interval for the difference in means was 7.71 to 23.66. The η^2 index was .18, which indicated a large effect size. Students who were in a Title I school as third graders in 2010 and as fifth graders in 2012 on average demonstrated higher mathematics achievement after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 13. Figure 9 shows the distribution for the two groups.

Table 13

Means and Standard Deviations and the 95% Confidence Interval of 2010 Grade 3 Students in Title I Schools

Student Group	N	M	SD	Confidence Interval
Before Specialist	73	743.86	32.62	7.71 to 23.66
After Specialist	73	759.55	39.65	

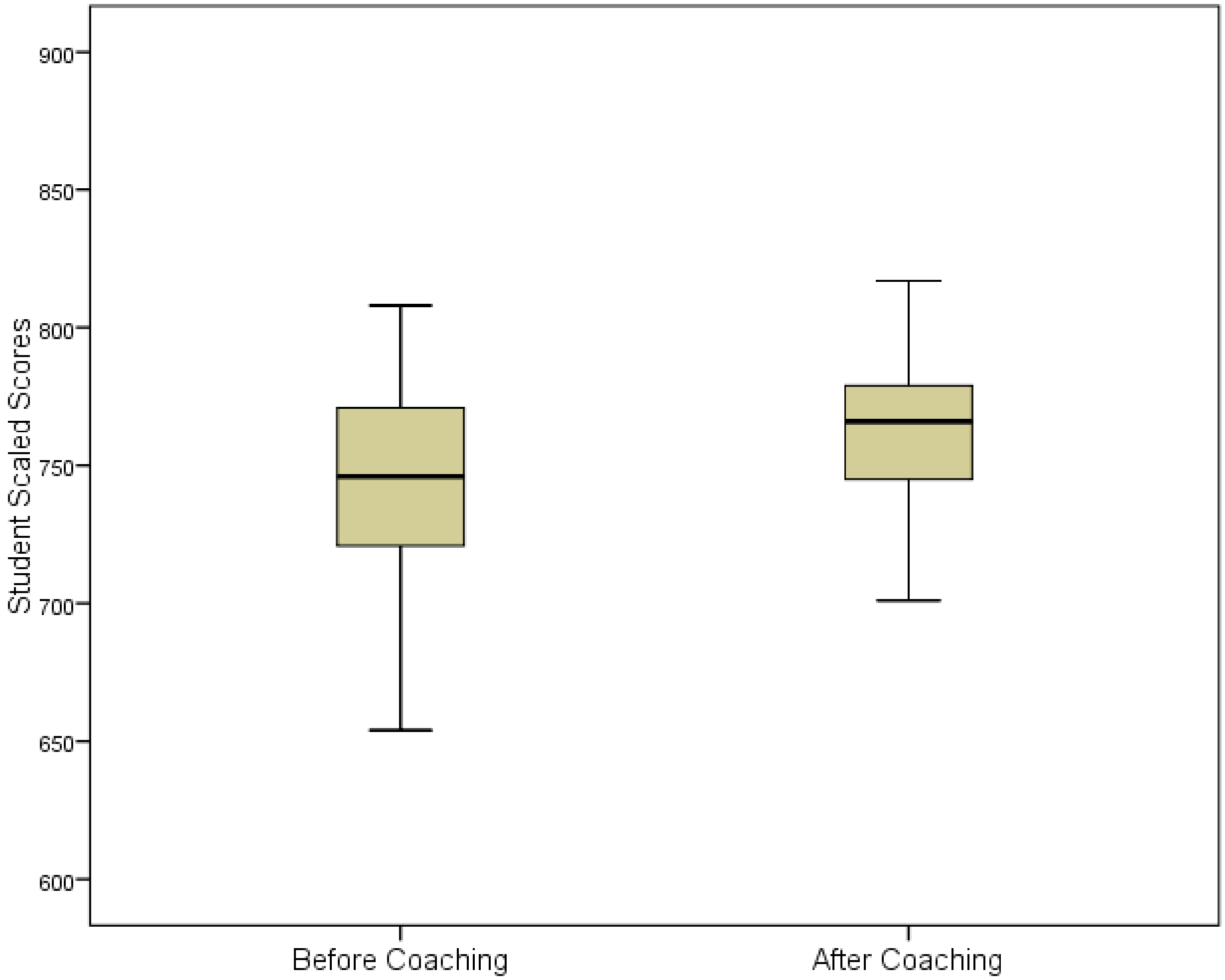

Figure 9. Distribution of Scores for Title I 2010 Grade 3 Students Before Specialist and After Specialist

H_02_4 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to non-Title I schools.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were non-Title I schools in third grade in 2010 and in fifth grade in 2012. There were three elementary schools in this category. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (160) = 9.81, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that fifth grade students' scores in 2012 (M = 784.66, SD = 28.99) were significantly higher than their third grade scores in 2010 (M = 765.32, SD = 33.96) with regard to non-Title I schools. The 95% confidence interval for the difference in means was 15.45 to 23.24. The η^2 index was .38, which indicated a large effect size. This group of students in non-Title I schools demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 14. Figure 10 shows the distribution for the two groups.

Table 14

Means and Standard Deviations and the 95% Confidence Interval of 2010 Grade 3 Students in non- Title I Schools

Student Group	N	M	SD	Confidence Interval
Before Specialist	161	765.32	33.96	15.45 to 23.24
After Specialist	161	784.66	28.99	

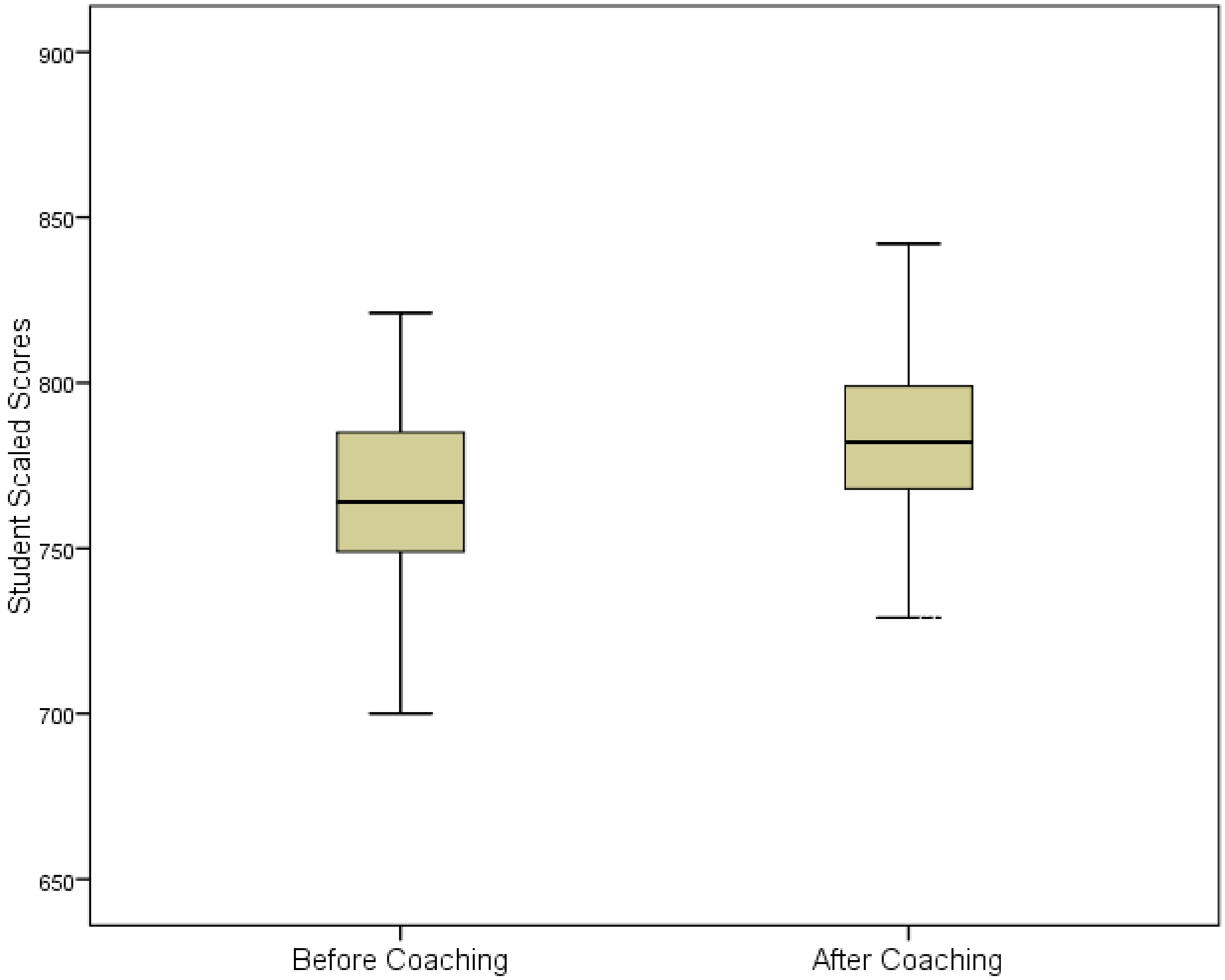

Figure 10. Distribution of Scores for non-Title I 2010 Grade 3 Students Before Specialist and After Specialist

H_02_5 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to Title I schools.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were in Title I schools in fourth grade in 2010 and in sixth grade in 2012. Two elementary schools were in this category. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (82) = 8.48, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that sixth grade students' scores in 2012 (M = 772.00, SD = 36.65) were significantly higher than their fourth grade scores in 2010 (M = 748.34, SD = 31.12) with regard to Title I schools. The 95% confidence interval for the difference in means was 18.11 to 29.21. The η^2 index was .47, which indicated a large effect size. This group of students in Title I schools demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 15. Figure 11 shows the distribution for the two groups.

Table 15

Means and Standard Deviations and the 95% Confidence Interval of 2010 Grade 4 Students in Title I Schools

Student Group	N	M	SD	Confidence Interval
Before Specialist	83	748.34	31.12	18.11 to 29.21
After Specialist	83	772.00	38.65	

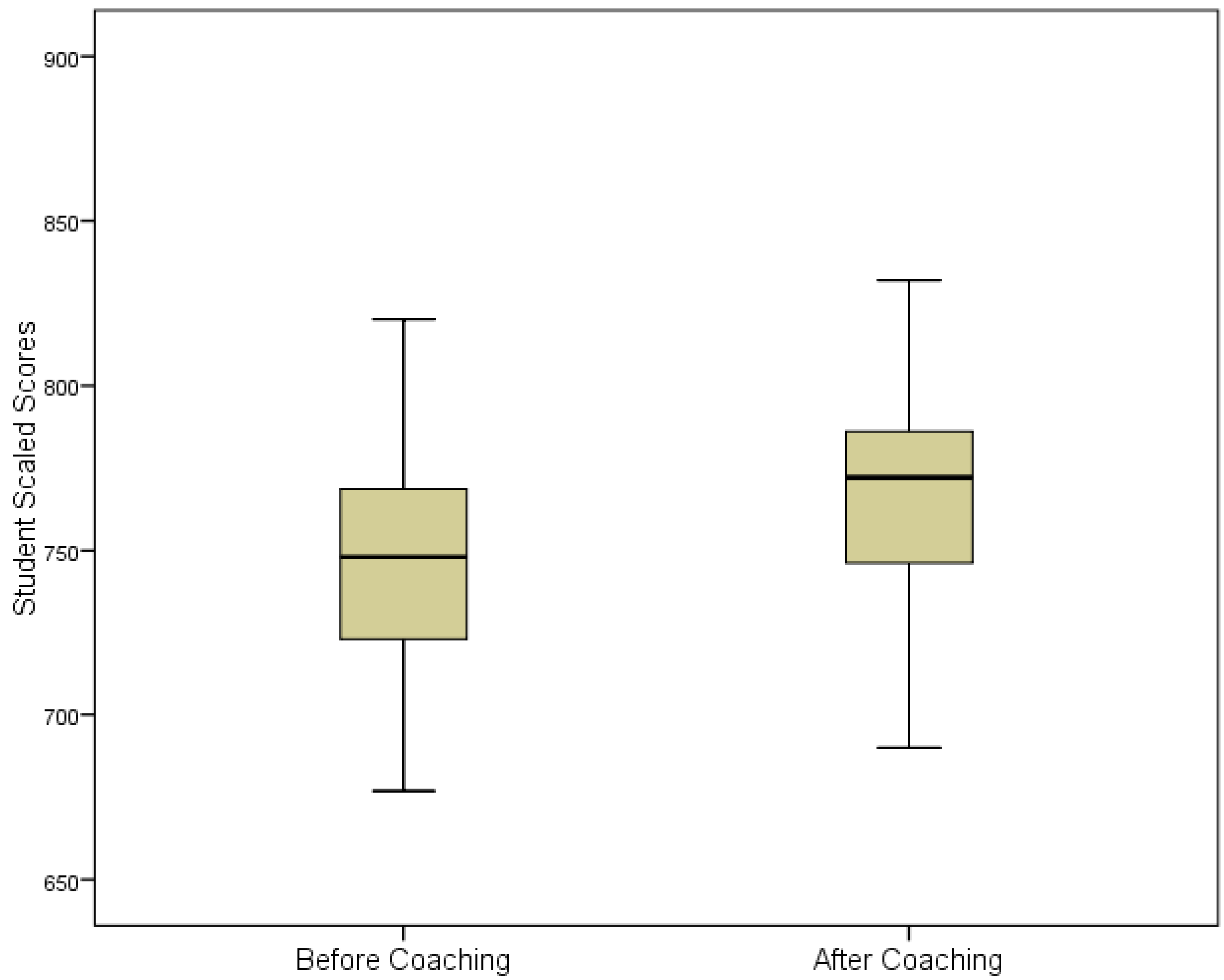

Figure 11. Distribution of Scores for Title I 2010 Grade 4 Students Before Specialist and After Specialist

$H_0 2_6$ There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to non-Title I schools.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were in non-Title I schools in fourth grade in 2010 and in sixth grade in 2012. Three elementary schools were in this category. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, $t\ (151) = 10.80$, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that sixth grade students' scores in 2012 (M = 780.17, SD = 42.09) were significantly higher than their fourth grade scores in 2010 (M = 755.68, SD = 33.03) with regard to non-Title I schools. The 95% confidence interval for the difference in means was 20.01 to 28.98. The η^2 index was .44, which indicated a large effect size. This group of students in non-Title I schools demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 16. Figure 12 shows the distribution for the two groups.

Table 16

Means and Standard Deviations and the 95% Confidence Interval of 2010 Grade 4 Students in non-Title I Schools

Student Group	N	M	SD	Confidence Interval
Before Specialist	152	755.68	33.03	20.01 to 28.98
After Specialist	152	780.17	42.09	

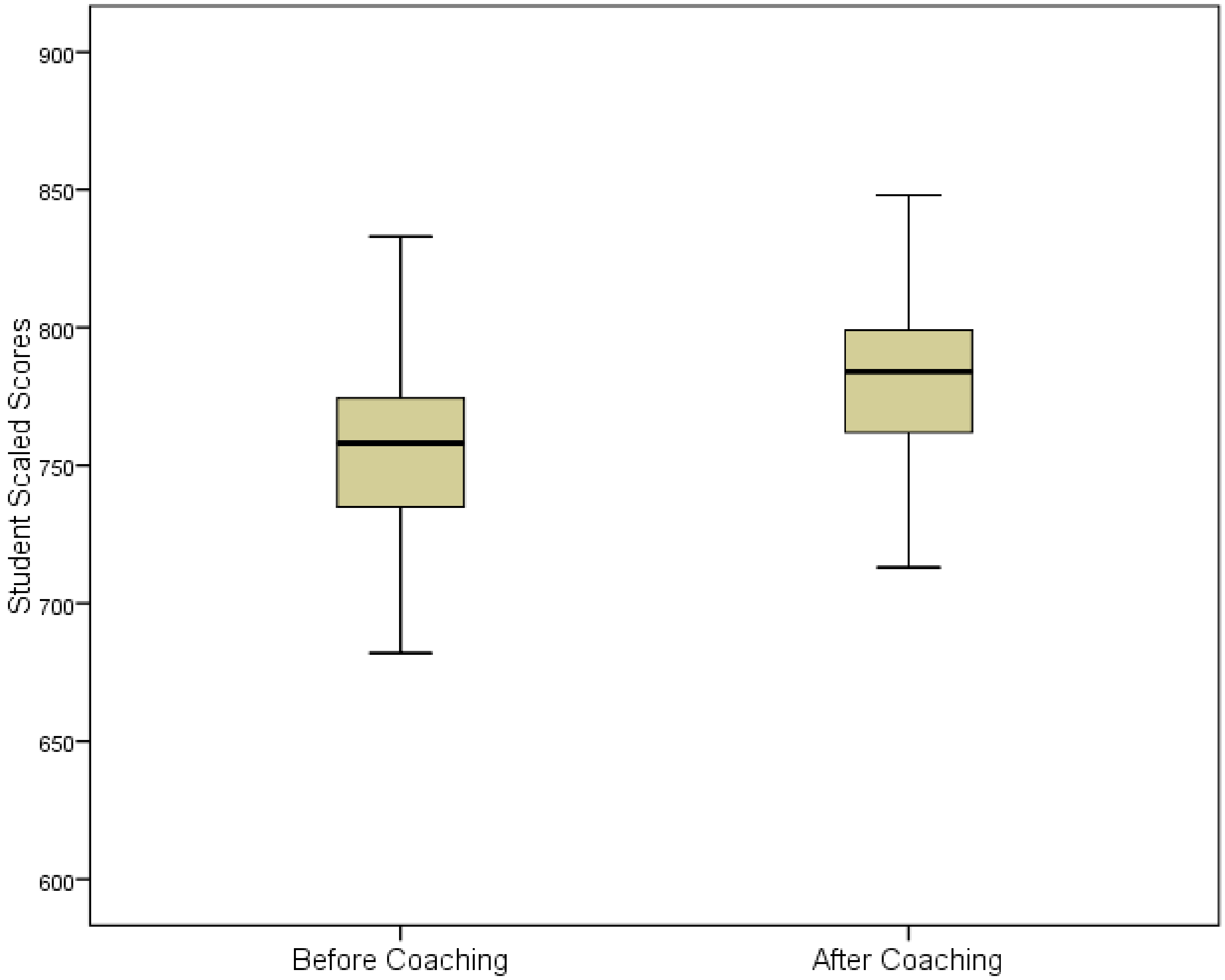

Figure 12. Distribution of Scores for non-Title I 2010 Grade 4 Students Before Specialist and After Specialist

H_02_7 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative) with regard to a Title I school.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were in a Title I and students who were in non-Title I schools in fifth grade in 2010 and in a Title I school in seventh grade in 2012 . In 2012 all these students were in grade 7 at the Title I middle school. The students in this test attended fifth grade in Title I and non-Title I schools in 2010. The dependent variables were 2010 and 2012 TCAP scaled scores that can vary from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, $t\ (226) = 15.03$, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that the scores of students who were in a Title I school in seventh grade in 2012 (M = 778.97, SD = 34.31) were significantly higher than their fifth grade scores in 2010 (M = 753.15, SD = 38.96) independent of the type of school they attended. The 95% confidence interval for the difference in means was 22.44 to 29.20. The η^2 index was .50, which indicated a large effect size. This group of students who were in a Title I school in 2012 demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 17. Figure 13 shows the distribution for the two groups.

Table 17

Means and Standard Deviations and the 95% Confidence Interval of 2010 Fifth Grade Students Who Attended a Title I Middle School

Student Group	N	M	SD	Confidence Interval
Before Specialist	227	753.15	38.96	22.44 to 29.20
After Specialist	227	778.97	34.31	

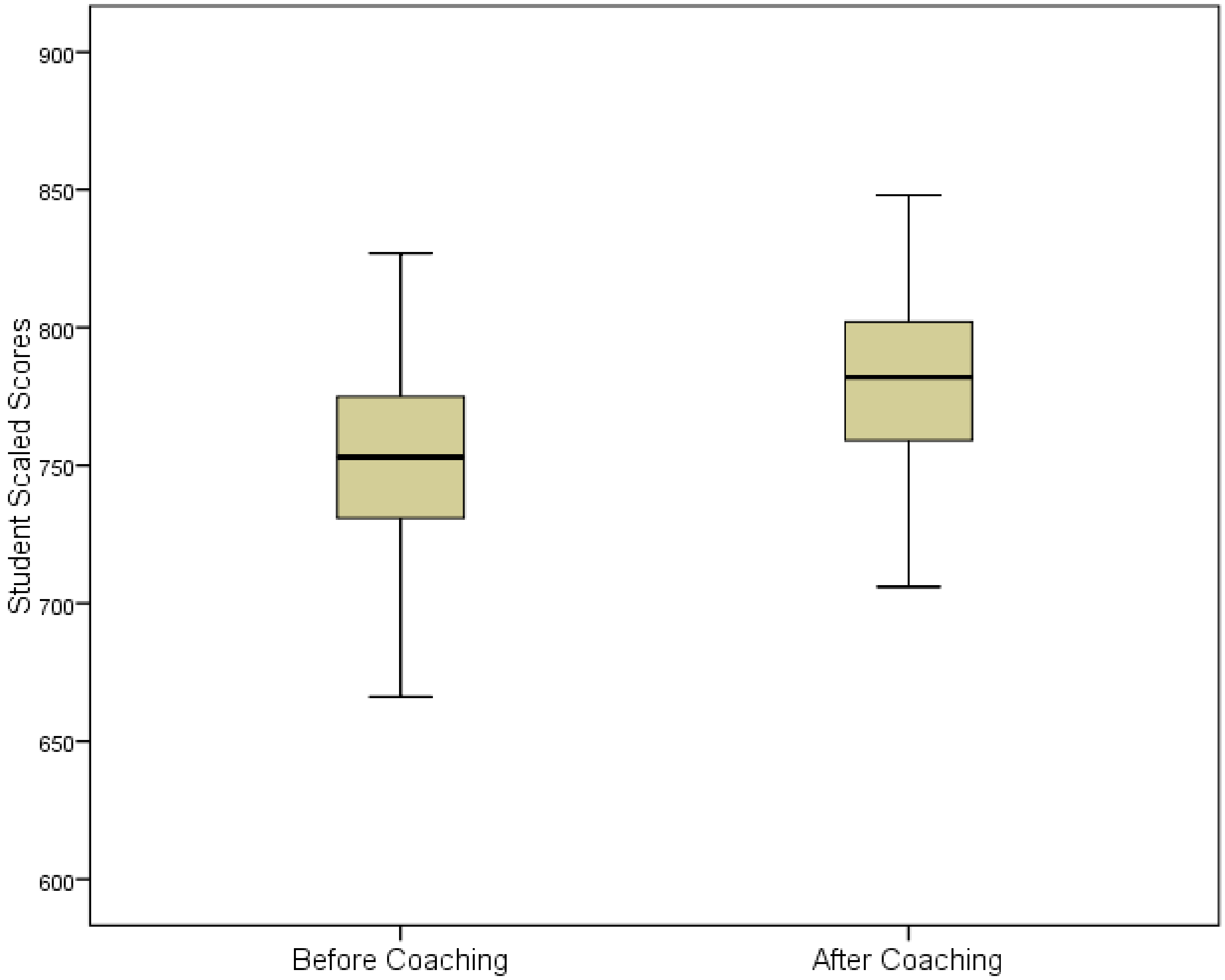

Figure 13. Distribution of Scores for 2010 Grade 5 Students Who Attended a Title I Middle School

H_02_8 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative) with regard to a Title I school.

To test this null hypothesis a paired-sample *t* test repeated measures was conducted to evaluate the difference in achievement levels measured by TCAP scores for students who were in Title I schools and students who were in non-Title I schools in sixth grade in 2010 and in a Title I school in eight grade in 2012. In 2012 all these students were in grade 8 at the Title I middle school. The students in this test attended both Title I and non-Title I schools in 2010. The dependent variables were 2010 and 2012 TCAP scaled scores that varied from 600 to 900. The independent variable was the presence or absence of mathematics coach or specialist. The *t*-test was significant, t (166) = 7.07, $p < .01$. Therefore, the null hypothesis was rejected. The results indicate that the scores of students who were in a Title I school in eight grade in 2012 (M = 753.17, SD = 29.53) were significantly higher than their scores in sixth grade in 2010 (M = 739.71, SD = 31.25) independent of the type of school they attended. The 95% confidence interval for the difference in means was 9.70 to 17.22. The η^2 index was .23, which indicated a large effect size. This group of students who were in a Title I school in 2012 demonstrated higher mathematics achievement scores on average after the specialist worked with teachers in those schools. The 95% confidence interval for the difference in means as well as the means and standard deviations for these students are reported in Table 18. Figure 14 shows the distribution for the two groups.

Table 18

Means and Standard Deviations and the 95% Confidence Interval of 2010 Grade 6 Students Who Attended a Title I Middle School

Student Group	N	M	SD	Confidence Interval
Before Specialist	167	739.71	31.25	9.70 to 17.22
After Specialist	167	753.17	29.53	

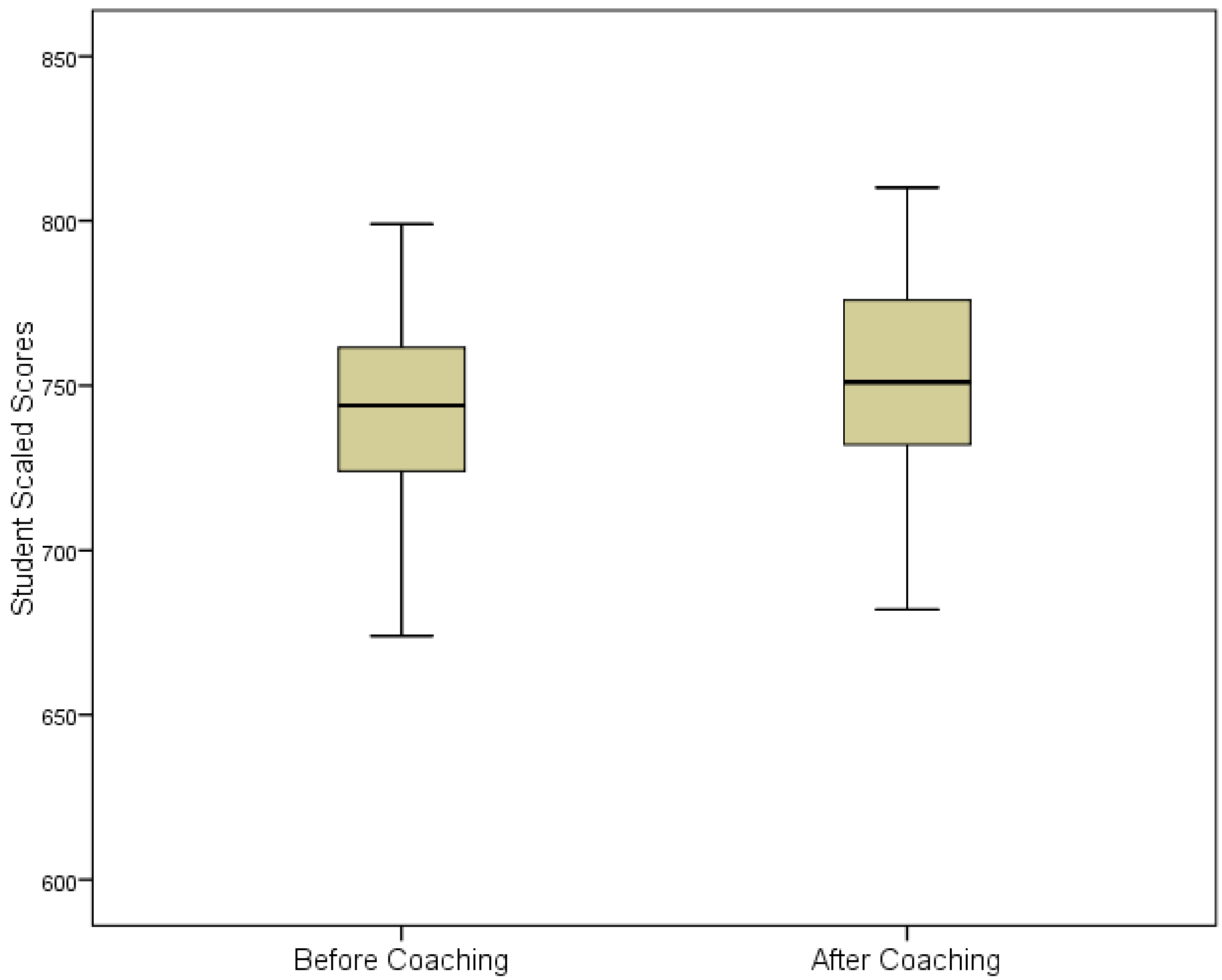

Figure 14. Distribution of Scores for 2010 Grade 6 Students Who Attended a Title I Middle School

Summary

Chapter 4 presented the statistical analysis that addressed the two research questions and their respective null hypotheses that I set out to investigate. There were two objectives described by the research questions. The first objective was to determine the difference in achievement levels as measured by TCAP scores for students in grade 3 – 6 and the use of a mathematics coach or specialist. The second objective was to study the difference in achievement levels as measured by TCAP scores for students who attended Title I and non-Title I schools and the use of a mathematics coach or specialist. The mathematical analysis demonstrated that mathematics coaching positively affected student achievement for students who attend both Title I and non-Title I schools. Chapter 5 presents a summary of findings, conclusions from the analyses, and recommendations for both practice and further research.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

Research confirms that what teachers know and do makes a difference in student achievement (Darling-Hammond, 2000). Therefore, it would seem important that schools and school systems explore ways to deliver appropriate professional development for their teaching force in order to increase student learning that ought to be the main focus of education. Desimone (2009) documented that traditional professional development such as one-shot workshops and conferences do not address the needs of most teachers. Academic coaching has been identified as a very promising professional development activity (Desimone 2011; Jeanpierre et al., 2005; Johnson et al., 2007; Penuel et al., 2007). Coaching offers the characteristics of effective professional development such as content-specificity, sustainability, collaboration, and coherence. Thus, a study of the relationship between academic coaching and student achievement can serve to aid school leaders as they invest in ways to provide effective professional development to their teachers as they pursuit ways to increase student achievement.

The purpose of this study was to investigate the difference in achievement levels of elementary school students as measured by TCAP scores and the use of a mathematics coach or specialist that was part of a mathematics improvement initiative in a Northeast Tennessee school system. Two research questions guided the study. The first question addressed significant differences in student achievement before and after the use of the mathematics improvement initiative as measured by TCAP scores. This question dealt with the student population in general, independent of the type of school. The second research question addressed significant differences in student achievement before and after the use of the mathematics improvement initiative as measured by TCAP scores with regard to Title I or non-Title I schools. I wanted to know if students in Title I schools could achieve at a higher level when the specialist coached their teachers.

The analyses were performed using SPSS software and analyzed at the .05 level of significance. The dependent variables were TCAP scores for the school year of 2009 – 2010 (before initiative) and 2011-2012 (postinitiative). The scores were collected from the district's central office. The independent variable was the presence or absence of mathematics curriculum coach or specialist.

Conclusions

A series of paired-sample repeated measures *t* test between TCAP scores before specialist and postspecialist addressed research question 1. Five null hypotheses were associated with this question. These hypotheses are restated below with their respective results.

H_01_1 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative). For this null hypothesis the test showed a statistically significant difference. The results indicate that students' scores after specialist (M = 772.94, SD = 36.76) were significantly higher than their scores before specialist (M = 752.02, SD = 35.27). Thus, the null hypothesis was rejected. Although the TCAP scaled scores for 2010 and 2012 do not present an overall scale for grades 3-6, the results would indicate these students tended to move from basic to the proficient range of scores.

H_01_2 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative). For this null hypothesis the test showed a statistically significant difference. The results indicated that these students' scores after specialist (M = 776.83, SD = 34.63) were significantly higher than their scores before specialist (M = 758.63, SD = 34.93). Thus, this null hypothesis was rejected as well. Although there was a statistically significant difference, these students tended to remain in the proficient category according to the TCAP scaled scores for 2010 and 2012.

H_01_3 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative). For this null hypothesis the test showed a statistically significant difference. The results indicate that these students' scores after specialist (M = 777.29, SD = 41.01) were significantly higher than their scores before specialist (M = 753.09, SD = 32.49). Thus, the null hypothesis was rejected. According to the TCAP mathematics scaled scores for 2010 and 2012 these students tended to move from basic to proficient.

H_01_4 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative). For this null hypothesis the test also showed a statistically significant difference. The results indicate that these students' scores after specialist (M = 778.97, SD = 34.31) were significantly higher than their scores before specialist (M = 753.15, SD = 38.96). Thus, this null was also rejected. According to the TCAP mathematics scaled scores for 2010 and 2012 these students tended to move from basic to proficient.

H_01_5 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative). For this null hypothesis the test showed a statistically significant difference. The results indicate that these students' scores after specialist (M = 753.17, SD = 29.53) were significantly higher than their scores before specialist (M = 739.71, SD = 31.25). Thus, this null hypothesis was rejected. Although there was a significant difference in scores, according to the TCAP mathematics scaled scores for 2010 and 2012, the difference was not sufficient to move these students from the range for basic.

The results indicated an overall increase in students' mathematics scores from 2010 to 2012. The biggest difference occurred in grades 4 and 5. According to the TCAP mathematics scaled scores, students in these grades were moved from basic to proficient. The smallest difference occurred for students in grade 6. This can be attributed to the fact that high achieving students who were in the sixth grade in 2010 did not take the TCAP test in 2012. Those students were enrolled in Algebra I class in eighth grade and they took the End of Course (EOC) assessment administered by the state to students in Algebra I.

Research question 2 addressed significant differences in student achievement before and after the use of the mathematics specialist as measured by TCAP scores with regard to Title I or non-Title I schools. There were eight null hypotheses associated with this research question. There are no null hypotheses concerning fifth and sixth graders who are in non-Title I schools because in 2012 these students attended the only middle school in the district, which is a Title I school. The null hypotheses with their respective analysis are presented below.

H_02_1 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to a Title I school. For this null hypothesis the test showed a statistically significant difference. The results indicate that students who attended Title I schools presented significantly higher scores after specialist (M = 767.51, SD = 36.13) than their scores before specialist (M = 747.11, SD = 35.18). Thus, the null hypothesis was rejected. Again, according to the TCAP scaled scores, students in Title I schools tended to show scores sufficient to move from basic to the proficient range of scores.

H_02_2 There is no overall significant difference between students' TCAP mathematics scores in 2010 (before initiative) and their respective scores in 2012 (postinitiative) with regard to a non-Title I school. For this null hypothesis the test showed a statistically significant difference. The results indicate that students who attended non-Title I schools demonstrated significantly higher scores after specialist (M = 782.48, SD = 35.96) than their scores before specialist (M = 760.64, SD = 33.80). Thus, the null hypothesis was rejected. Students in non-Title I schools tended to show differences that were not sufficient to move them from one level to another. They remained in the proficient range of scores.

H_02_3 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to Title I schools. For this null hypothesis the test showed a statistically significant difference. The results indicate that fifth grade students who attended Title I schools in 2012demonstrated significantly higher scores (M = 759.55, SD = 39.65) than their scores in third grade in 2010 (M = 743.86, SD = 32.62). Thus, the null hypothesis was rejected. According to the TCAP scaled scores for 2010 and 2012 students in this category tended to move from basic to proficient.

H_02_4 There is no significant difference between TCAP mathematics scores of third grade students in 2010 (before initiative) and their scores as fifth graders in 2012 (postinitiative) with regard to non-Title I schools. For this null hypothesis the test showed a statistically significant difference as well. The results indicate that fifth grade students who attended non-Title I schools in 2012 displayed significantly higher scores (M = 784.66, SD = 28.99) than their third grade scores in 2010 (M = 765.32, SD = 33.96). The null hypothesis was rejected. Although there was a significant difference in scores, these students tended to stay in the proficient range according to the TCAP scaled scores for 2010 and 2012.

H_02_5 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to Title I schools. For this null hypothesis the test showed a statistically significant difference as well. The results indicate that students in Title I school in sixth grade in 2012demonstrated significantly higher scores (M = 772.00, SD = 36.65) than their scores in fourth grade in 2010 (M = 748.34, SD = 31.12). The null hypothesis was rejected. According to the TCAP scaled scores for 2010 and 2012 students in this category tended to move from basic to proficient.

H_02_6 There is no significant difference between TCAP mathematics scores of fourth grade students in 2010 (before initiative) and their scores as sixth graders in 2012 (postinitiative) with regard to non-Title I schools. For this null hypothesis the test showed a statistically significant difference as well. The results indicate that students in non-Title I schools in sixth grade in 2012 showed significantly higher scores (M = 780.17, SD = 42.09) than their scores in fourth grade in 2010 (M = 755.68, SD = 33.03). The null hypothesis was rejected. According to the TCAP scaled scores for 2010 and 2012 students in this category tended to move from basic to proficient.

H_02_7 There is no significant difference between TCAP mathematics scores of fifth grade students in 2010 (before initiative) and their scores as seventh graders in 2012 (postinitiative) with regard to a Title I school. For this null hypothesis the test showed a statistically significant difference as well. The results indicate that students in a Title I school in seventh grade in 2012 presented significantly higher scores (M = 778.97, SD = 34.31) than their scores in fifth grade in 2010 (M = 753.15, SD = 38.96) independent of the type of school they attended. Thus, the null hypothesis was rejected. According to the TCAP scaled scores for 2010 and 2012 students in this category tended to move from basic to proficient.

H_02_8 There is no significant difference between TCAP mathematics scores of sixth grade students in 2010 (before initiative) and their scores as eighth graders in 2012 (postinitiative) with regard to a Title I school. For this null hypothesis the test showed a statistically significant difference as well. The results indicate that students in a Title I school in eight grade in 2012 presented significantly higher scores (M = 753.17, SD = 29.53) than their scores in sixth grade in 2010 (M = 739.71, SD = 31.25) independent of the type of school they attended. Thus, the null hypothesis was also rejected. Although there was a significant difference in scores, these students in this category tended to stay in the proficient basic according to the TCAP scaled scores for 2010 and 2012.

The results for research question 2 demonstrated that there was an overall statistically significant difference in mathematics scores for all groups with regard to Title I or non-Title I schools. Students in grades 3, 4, and 5 in Title I schools in 2010 moved from basic to proficient, according to the TCAP scaled scores. Fifth grade students who attended Title I schools displayed the largest difference in mean scores before specialist and after specialist. Students who attended Title I schools in grade 6 displayed the smallest difference in mean scores. Similarly to research question 1, this can be attributed to the fact that high achieving students who were in the sixth grade in 2010 did not take the TCAP test in 2012. As eight graders those students were enrolled in Algebra I class and they took the End of Course (EOC) assessment administered by the state to students in Algebra I.

Recommendations for Practice for Coaches and Districts

The findings from this study indicate a strong correlation between the use of academic coaching in mathematics and students' mathematical achievement as measure by TCAP scores. The correlation occurs in both Title I and non-Title I schools and in grades 3 – 6. These findings are congruent with the findings reported by Campbell and Malkus (2011). They stated that over time students in grades 3, 4, and 5 in five school districts in Virginia where coaching was present achieved significantly higher than students in schools were mathematics coaching was not present.

The results of this study suggest the following practices for a mathematics coach:

- Coach to respond to teacher or principal request for assistance. The coach in this study was available when requests were made by building principals and teachers.
- Meet and discuss with teachers content to be addressed or improved. The coach used curriculum guides and pacing charts to decide on content to be addressed.
- Observe teacher. The coach observed teacher and met later to discuss teaching strategies.
- Design and/or assistance with lesson design. The coach found resources and assisted in lesson design when requested by teachers.
- Coteach lesson upon teacher request. The coach cotaught lessons and worked with small groups of students.

- Design and present workshops for teachers. The coach presented in-service activities that addressed teachers' deficiencies.
- Invite guest speakers to address teacher need as determined by teacher. The coach invited presenters, such as university professors, to present topics selected by coach and/or teachers.
- Help design and administer assessment. The coach used computer software to design computer-based assessment.
- Search for internet resources that address teacher needs.
- Provide technology training and on-going support. Coach worked with technology department to schedule technology training.
- Respect teachers' opinions and use feedback as a tool self-improvement. Coach sough feedback from teachers on professional development activities.
- Help teachers with mathematical pedagogical content knowledge. Coach assisted teachers with hard to grasp mathematics content and ways to present it.

The study also suggests that school districts should demonstrate long-term commitment to coaching initiative independent of short-term results. This means that either low or high test scores do not guide the decision about continuing with initiative. The decision to continue or discontinue with specialist must not be made simply based on immediate results.

Recommendations for Further Research

Further studies on academic coaching initiatives need to be done in order to determine its effectiveness under more controlled circumstances. It is recommended that these studies control for and investigate the conditions outlined below:

- Preparation of academic coach prior to engaging in coaching function. Campbell and Malkus (2010) documented that the state of Virginia invested in intensive training for coaches for its mathematics coaching force. Anstey and Clarke (2010) also outlined several skills that coaches need before they actively engage in coaching.
- Document time the coach spent with every individual teacher or group of teachers. Studies need to be carried out on the correlation between time spent in academic coaching and student achievement. The Campbell and Malkus (2010) offered details on the use of technology to keep track of time spent on coaching.
- How the coach interacted with each teacher. Part of the success of the coaching initiative is the trust that must be developed between coach and teacher. Murray et al. (2009) noted teachers' positive perception of a peer coaching activity. Kohler et al. (1997) reported that teachers were more willing to try innovative initiatives when supported by colleagues.
- How coach responded to teacher feedback. The literature is scarce on how coaches collected and responded to teacher feedback.
- How the academic coach was perceived by teachers and building principal. Neuberger (2011) reported on a coaching initiative in New York that successful in part because the principal and teachers viewed the coach as a partner in the student learning process.

- How teacher knowledge and beliefs interfere with coaching experience. More research is needed that investigate how the teacher views the coach. Although the literature reports that teachers respond positively to academic coaching, one study (Horne, 2010) found that teachers did not view coaches as influencing achievement.
- How the teachers' pedagogical style and classroom practices changed due to coaching. Several studies reported that coaching had a positive effect on teacher practice. Several researchers have come to the conclusion that change in teachers' instructional practices, strategies, and techniques is one of the most direct outcome of peer coaching (Bruce & Ross, 2008; Murray et al., 2009; Nickerson, 2009). Kohler et al. (1999) stated that as a result of a peer coaching activity adapted their instructional practices to serve students more effectively. Walpole et al. (2010) studied coaching behaviors that effectively promoted change in teachers' practices.
- The degree that teachers grew though other professional development initiatives such as summer programs, university courses, school-based professional learning communities, and self-directed growth. The literature reviewed for this study presented cases where the coach received training through various sources (Becker, 2001; Malkus & Campbell, 2011; Murray et al., 2009), but very few presented how the teacher grew as a result of other professional development initiatives.

Summary

The idea for this study originated from my curiosity about the relationship between mathematics academic coaching and elementary school students' mathematical achievement. Educators are under constant pressure from society at large and policy makers to adequately prepare our children to be productive citizens and compete in a global economy that demands mathematically literate members. Mathematics literacy is considered a survival skill.

The extant literature documents several functions performed by academic coaches as well as the tremendous possibilities that coaching offers in regards to in-service teachers' professional development. I evaluated the difference in mathematics achievement levels of elementary school students due to a mathematics improvement initiative in a Northeast Tennessee school district. Despite its limitations, the study demonstrated that student achievement in mathematics increased significantly after academic coaching was provided to teachers in grades 3 – 6. The study also demonstrated that student mathematics achievement increased regardless of whether students attended a Title I or a non-Title I school.

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APPENDICES

APPENDIX A

Permission to Conduct Research

Permission to Use Data

April 29, 2013

Dr. Gary Lilly
Bristol Tennessee City Schools
615 Martin Luther King Jr. Blvd
Bristol, TN 37620

Dear Dr. Lilly,

I am writing this letter to request your permission to use Bristol Tennessee City Schools TCAP test data for grades 3 through 6, for the school years of 2009-2010, 2010-2011 and 2011-2012. I am completing a doctoral dissertation at East Tennessee State University. The study relates to the relationship between the use of a mathematics academic coach, or specialist, and student achievement as measured by the TCAP scores. The study also controls and investigates the relationship in regard to Title I schools.

The confidentiality of all individuals involved will be protected. If these arrangements meet with your approval, please sign this letter where indicated below. Thank you very much for your continued support of this project that I hope will benefit our students and faculty.

Sincerely,

Evandro R. Valente
Evandro R. Valente

I hereby grant Evandro R. Valente permission for the use of data as requested above, as long as no individual identifiable information is revealed.

Gary Lilly
Dr. Gary Lilly
Bristol Tennessee City Schools Director of Schools

5/3/13
Date

APPENDIX B

IRB Approval

ETSU

East Tennessee State University

Office for the Protection of Human Research Subjects • Box 70565 • Johnson City, Tennessee 37614-1707
Phone: (423) 439-6053 Fax: (423) 439-6060

June 10, 2013

Evandro R. Valente
213 Melody Lane
Bristol, TN 37620

Dear Evandro Valente,

Thank you for recently submitting information regarding your proposed project "Mathematics Curriculum Coaching and Elementary School Student Achievement in Tennessee School System."

I have reviewed the information, which includes a completed Form 129.

The determination is that this proposed activity as described meets neither the FDA nor the DHHS definition of research involving human subjects. Therefore, it does not fall under the purview of the ETSU IRB.

IRB review and approval by East Tennessee State University is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities are human subject research in which the organization is engaged, please submit a new request to the IRB for a determination.

Thank you for your commitment to excellence.

Sincerely,
Chris Ayres
Chair, ETSU IRB

Full AAHRPP Accreditation — Association for the Accreditation of Human Research Protection Programs, Inc.

Accredited Since December 2005

VITA

EVANDRO R. VALENTE

Personal Data:	Date of Birth: July 26, 1960 Place of Birth: Itaiçaba, Ceará, Brazil Marital Status: Married
Education:	Presbyterian Pan American School, Kingsville, Texas B.S. Physics, King College, Bristol, Tennessee 1984 B.S. Electrical Engineering, Georgia Institute of Technology Atlanta, Georgia, 1985 M.Ed. Vanderbilt University, Nashville, Tennessee, 1995 Ed.D. East Tennessee State University, Johnson City, Tennessee, 2013
Professional Experience:	Electrical Engineer, Telebrás, Campinas, Brazil 1986-1989 Electrical Engineer, Tri-Cities Ind. Bldgs, Bristol, Tennessee, 1989-1994 Mathematics Teacher, Tennessee High School; Bristol, Tennessee, 1995- Present
Honors:	Tandy Outstanding Teacher, 1998-1999. Teacher of the Year by colleagues in 1999. Coach of the Year in Northeast TN 1997-1998. Toyota International Teacher Program, 2006 Teacher of the Year 2007 – 2008 McGlothlin Teaching Excellence Award Finalist